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METROPOLITAN WATER SUPPLY SYSTEMS[1]

BY MORRIS KNOWLES[2] AND JOHN A. FULKMAN[3]

A metropolitan water supply system results where a number of cities, boroughs or other municipalities are joined together, in a combined unit for the common benefit. Such benefit accrues to health and finance.

According to the 1920 census, over 50 per cent of the population of the United States lives in communities of over 2500 population. There is a growing tendency for people to live in cities, as shown by the following figures computed from census for the last two decades:

YEAR	PER CENT OF POPULATION IN CITIES	
	Over 8,000	Over 100,000
1900	33.1	19
1910	38.9	22
1920	44.1	26
1923	45.0	27

There is also a growing tendency for the population to centralize around large cities. This was exemplified in the decade 1900 to 1910, when twenty-five cities in North America of over 200,000

[1] Presented before the Central States Section meeting, December 6, 1924.
[2] Consulting Engineer, Pittsburgh, Pa.
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inhabitants increased 33 per cent; while that of the district lying outside, but within 10 miles of the city, increased 43 per cent. There has been greater increase within the last ten or fifteen years, on account of the automobile and better means of communication. In these days of the rapidly growing use of the automobile, living ten or fifteen miles from the center does not cause any inconvenience, if one can find a place to park his machine when he gets to the city.

NEED OF COMMUNITY COÖPERATION

Mutual inter-effects

People reside in the suburban town and go to their daily work in the central city; industries in one municipality draw many of the working force from another; stores in the city secure trade with all the surrounding communities, and salesmen and delivery trucks are constantly circulating throughout the district. Improved transportation, highways and the use of automobiles have enlarged the social horizon of every individual and cause a constant interchange.

None of us "lives to himself" and cities and suburbs are all "members one of another." Just the other day President Coolidge made a speech at the Commercial Club luncheon at Chicago on this topic. The daily newspapers carried the following headline describing this speech, "Nations can not live to themselves alone." It is an established fact that we are dependent upon others for the food we eat, the shoes and clothes we wear, and the automobiles in which we ride, but most of them are dependent upon us for the water used.

A bad water supply in one suburb may cause sickness throughout the district; an epidemic in one town may spread to our neighbors. Water supply, drainage and sewage problems cannot be solved within man-made political boundaries alone, but must be treated as watershed problems.

Conservation of resources

The conservation of resources is becoming more important in the United States each year, particularly of those resources represented by flowing and underground waters. The quantity of water available for the various uses of a region is strictly limited, and if the greatest good is to be obtained not only the needs of all the municipalities involved must be considered, but study must be given also to

all the uses for such supply. These include domestic water, sewage disposal, power development, irrigation and water transportation.

Our large cities and thickly populated districts are having to go farther and farther out from the city to secure water of a sufficient quantity and of a proper quality. New York City has gone 92 miles into the Catskill Mountains; the City of Tulsa, Oklahoma has just completed a water supply, which is obtained 58 miles from the city, at the foot of the Ozark Mountains, San Francisco some 80 miles, and Los Angeles 257 miles to the Owen's Valley.

Economy in construction and operation

Within reasonable limits, large scale production pays, in public service as it does in industry, because it reduces overhead cost per unit of production. This point has been illustrated, in the last few years, in the electrical industry, where large central stations furnish both power and light to districts within a radius of 50 to 100 miles. The electrical industry is able to take care of districts of much larger extent than it could a few years ago, mainly due to the fact that electrical engineers have discovered methods of transmitting electricity with much less loss than was necessary a few years back.

If some of our waterworks engineers would discover some method whereby the loss of head from flow in pipe lines could be reduced, we might increase the metropolitan areas to take in much larger districts than we think of today. In fact then we might think of supplying a large portion of the area near the Great Lakes from such lakes instead of from inland rivers. Of course if this Great Lakes source of water supply were to be developed extensively it might not be long until we would hear the criticism that immense amounts of water are being taken and thus causing a reduction of the level of the lakes; just as we are hearing at the present time, in connection with the water being taken from Lake Michigan by the Sanitary District of Chicago.

Political morality

As we are mutually dependent, such neighborly relations involve mutual obligation. It is dishonest to enjoy benefits without paying part of the cost (of course in these days of high cost of living, we do not receive much of anything for nothing), just as it is unfair to be subjected to disadvantages without having an opportunity to assist in eliminating them.

EXAMPLES OF SECURING CENTRALIZED CONTROL

Annexation

The oldest method of securing centralized control, and the one that has been resorted to in the growth of the region around practically every city, is annexation. This results in actual incorporation of adjacent territory into the city, and complete centralization of authority with respect to public works, public safety, taxation and all other municipal functions. This may be brought about by mutual agreement between the city and the annexed suburb, or, under some forms of legislation, by a majority of all the voters in the territory affected, regardless of the wishes of the voters of the suburb to be annexed.

There is, no doubt, some advantage in the advertising value to business houses, banks, commercial institutions, even perhaps to the common citizen, in being able to refer to the city as larger than some competing neighbor. The large city no doubt is better able to attract new industries and to finance larger and more expensive public improvements. There is perhaps some real justification for the pride that is frequently taken in the figures published in a census report. Furthermore, it is true in some instances that the territory lying adjacent to the city is completely continuous with it in development, so homogeneous with it in the population and interest that consolidation may be the best possible solution of the problem.

Size, however, does not always spell economy and efficiency. With the growth of the city the old fashioned "town meeting" becomes impossible for the purpose of expressing the desires of the citizens. It is difficult for the voters to keep in touch with the action of their elected representatives. The problems of municipal government become increasingly complex, and difficult, leading too often to misgovernment and dishonesty. A further disadvantage of annexation is the loss of local civic spirit, which is difficult to keep alive in a large modern city.

For all of these reasons, annexation is not always looked upon with favor; particularly where the boundaries between adjoining communities are still distinct, where the people are not homogeneous, and where the local interests at some points conflict. Under such circumstances, there are additional disadvantages in consolidation, for, if acquiescence of the citizens of the territory to be annexed is to be secured, it is often necessary to make undesirable concessions.

And if the territory taken in is against the wishes of a majority of the citizens, and antagonistic spirit is engendered that may take many years to eliminate.

As examples of annexation, almost any large city may be cited, for instance, New York City, Philadelphia, Pittsburgh—all of which solve their combined water supply problems much more advantageously on account of consolidation.

Extension of municipal jurisdiction

This method has been used most commonly in connection with town planning and approval of lot plans, but has been suggested for other municipal functions. The states of California, Ohio and Wisconsin have laws whereby cities, which have planning commissions, have the right to approve adjoining plats. Pennsylvania passed a law giving third class cities the right to approve plats for a distance of three miles beyond the city limits. In Virginia there is a law giving cities over 50,000 similar authority for a distance of twenty miles beyond the city limits.

Contracts between municipalities

This arrangement is not uncommon in the case of relatively simple services capable of exact definition and accurate measurement. The supply of water answers these requirements admirably and numerous examples of coöperative service of this sort under contracts may be found. The City of Pittsburgh, for example, sells water upon occasions of need to several adjoining municipalities When the new Allegheny Water Works System (now part of Pittsburgh) was built a line was laid north of the Allegheny River, through the Boroughs of Aspinwall, Sharpsburg, Etna and Millvale, all of which were given an emergency connection, as part compensation for being allowed to use the public streets. Each Borough still maintains its own system which have been inadequate at several times, both as to quantity and quality. Several occasions have risen when it has been necessary to supplement the Borough supplies.

In 1923, the Borough of Homestead, a borough of some 20,000, solved its water supply problem by laying a line across the Monongahela River and arranged to purchase water from the City of Pittsburgh. Cleveland, Ohio, sells water to neighboring cities and to a dozen suburban villages. The City of Chicago furnishes water to

seven adjacent cities and towns, as required by the provisions of the act creating the Sanitary District of Chicago.

The City of Elyria, Ohio, supplies water to Amherst and a large territory lying along its lines from the supply works on Lake Erie to the city, some nine miles back from the lake. In 1920, when an additional line was laid from the Lake towards Elyria, it paralleled the old lines for a distance of about three miles. It then took a different direction for the purpose of coming into the distribution system at Elyria on a different side of the city and also to be able to take care of a section being rapidly built up in the County between Elyria and Lorain.

The City of Lorain at the present time does not supply any water outside of its limits. Had it not been for the dreadful tornado that visited Lorain on June 28th of this year it would no doubt be supplying two villages which have not been able to install a distribution system on account of the heavy losses incurred by the tornado.

County administration

Chicago and Philadelphia are sometimes referred to as they are co-extensive with their counties, but these are not especially good illustrations of county administration as the governing body is still separate. The London City Council which has charge of many of the municipal functions of the London Metropolitan District is frequently cited as an example of its success. Jefferson County, Alabama has constructed and maintained a trunk sewer and disposal plant for handling the sewage of the cities of Birmingham and Bessemer, and the adjoining portions of the county. The organization of the Sanitary Districts in Ohio, for sewers and water, can be considered for practical purposes, such form of county administration.

Private enterprise

Practically every large city also presents examples of centralized control of municipal utilities, extending into numerous political subdivisions and under private ownership. Examples of water companies are the East Jersey Water Company and the Hackensack Water Company, supplying the urban districts of Northeastern New Jersey; Springfield Consolidated Water Company, supplying the entire suburban territory surrounding the City of Philadelphia; the Pennsylvania, South Pittsburgh, Ohio Valley, Suburban, and

Beavor Valley Water Companies supplying extensive districts, including numerous municipalities in Western Pennsylvania.

Metropolitan districts

A great many of the defects of the methods of organization previously described may be avoided by the organization of neighborhood cities and adjoining suburban areas, for particular purposes, into metropolitan districts. Such districts, organized usually by particular legislation under the direction of representative commissions, leave the political functions of municipalities untouched, and thus preserve "home rule" and encourage local initiative and civic spirit. By confining their activities to specified public services, they tend to avoid the danger of political interference; by representative government, they protect the suburban municipalities from the domination of the larger cities; by including selected territory, the inequalities of county administration are avoided; and they can be adjusted to situations beyond the scope of any contract that might be drawn beforehand. Thus all of the economy and efficiency of private enterprise is possible of attainment, with none of the objections to private ownership. In other words, the metropolitan district may achieve most of the advantages of the other types of organization described, while avoiding most of their undesirable features.

It must not be supposed that there are not pitfalls to be avoided in organizing a metropolitan district. The difficulty of securing complete representation, sometimes leads to opposition on grounds of "taxation without representation." The development of works ahead of immediate needs is apt to be criticized, but with wise planning only the general plan and a few permanent works need be designed for future conditions, the greater part of the construction being carried out from time to time as it is required.

The distribution and apportionment of the cost, and the determination of what part, if any, shall be borne by territory not yet developed, but which will be brought into development by the building of such works are all difficult and have proved to be the rocks upon which many a good scheme has been wrecked. None of these dangers, however, is inherent in the method, and all of them may be avoided if local pride and self-interest can be eliminated and if a broad, public-spirited view of the situation will be taken by all.

Regarding these personal, as compared with physical, obstacles

no better statement can be made than that of the late General H. M. Chittenden, in commenting upon the legal and political difficulties met in connection with the great regional undertaking of the Miami Conservancy District.

The greatest obstacles that the promoters of public work have overcome are not those of nature but of man. Nature is sometimes a stubborn adversary, but she always acts in the open, without subterfuge or indirection. But human ignorance, prejudice and self-interest are handicaps of a different character. Ignorance is least important, because it may yield to instruction. Prejudice—that is, prejudgment of a case and then sticking to it regardless of facts—is immeasurably worse. But self-interest is the most insuperable obstacle of all. Public measures are judged by their effect on the private pocketbook, and the rarest phenomenon in the world is willingness to subordinate personal interest to the public welfare.

APPORTIONMENT OF COST

Like the problem of organization, apportionment of cost is, in a a large degree, a financial, legal, and political problem. But like the selection of organization types, it is so closely bound up with the use of public works, that it is well for the engineer, for his own good as well as the good of the community, to affiliate himself with such problems.

General taxation

General taxation requires no definition. It would provide simply that the portion of the cost of work would be disbursed out of the funds of the region, state or nation, and assessed upon taxable property, real and personal, or upon incomes by the proper authority, in the same manner as that in which all of the taxes are assessed. It would be applicable only to the portion of the cost of works chargeable to the general interest, and would be normally confined to the region benefited by the works.

In some states, however, as for example in Pennsylvania, the creation of special taxing districts is now understood to be prohibited by the constitution. Contributions to the cost of works can be secured, however, from the municipal, county, state and national governments.

Special assessment

The method of special assessment, although originally an English idea, has had its greatest development in the United States. On the continent of Europe, only Belgium and Germany have used this

principle to any considerable extent. Its history in Great Britain, however, covers more than two centuries. The first law was passed in 1662, authorizing the widening of certain streets in Westminster; and after the London fire of 1666, a similar act was passed to provide for the rebuilding of the city. In New York in 1676, the cost of digging wells for a water supply on Broadway and Pearl Street was assessed, one-half to the city and one-half to the property holders nearest the wells. The comprehensive special assessment law enacted for New York in 1861, is said to have been the first in the United States.

The theory underlying special assessments is that the property on which they are imposed receives particular benefits, and that general taxation for such purely individual purposes is unjust. Any community, individual, or land that receives a particular advantage should pay for it in proportion to the benefit derived. Also, there should be no assessment in case no benefits are derived, and, as has been held by some court decision, "Burdens in excess of benefits . . . . must be borne by general taxation." T. M. Cooley in his "Treatise on the Law of Taxation," states the rule as follows:

> The only safe and practicable course, and the one which will be equal justice to all parties, is to consider what will be the influence of the proposed improvements on the market value of the property, what the property is now fairly worth in the market and what will be its value when the improvement is made. . . . . There can be no justification for any proceeding which charges the land with an assessment greater than the benefits. It is a plain case of appropriating private property for public use without compensation.

In Pennsylvania, the use of special assessments has been materially limited by court decisions, restricting such assessments to certain kinds of improvements, and to property immediately abutting thereon; whereas, special benefits may frequently be conferred over a considerable area in addition to abutting property. Both constitutional and legislative changes are desirable in order that this useful, and reasonable, method of paying for public improvements may be properly employed.

Excess condemnation

A special application of the principle underlying the theory of special assessments is excess condemnation, which has come into vogue within the last few years in a number of the states. It fre-

quently happens that, in carrying out a public improvement, the full benefit cannot be obtained from it, nor can the full contribution to the cost which such benefit would justify be obtained, unless more property than that actually needed for the improvement is taken and replanned for new uses in harmony with the improvement.

Several of the states have authorized municipalities, in such cases, to condemn such additional property in excess of the necessities of the project and, upon completion of the improvement, to resell the excess at its increased value.

Such a provision is reasonable and just, in so far as it contributes to the carrying on of the project in such a manner as to accomplish the maximum possible benefit of the community.

Rates

This method of apportioning cost is applicable, especially to public utility services, such as steam and electric transportation, light and power systems, and joint water supply and sewerage systems. The determination of reasonable rates, so as to apportion fairly the necessary gross revenue, is an intricate economic and engineering problem, and public supervision by a utility commission is required to make sure that they are maintained at a reasonable level.

Some instructive examples of combinations of methods of apportioning cost are found at Boston, and Passaic, N. J.; and at Winnipeg, in Canada. These are described below.

Examples

Boston methods. The most notable examples of metropolitan financing in the United States are those of the Boston Metropolitan District for sewerage and water-works. As originally proposed, the assessments for the construction of the trunk sewers and disposal and outfall works were to be determined by three commissioners appointed by the Supreme Judicial Court, allotments to be made each five years in advance. No basis was stipulated in the original act. In 1906 it was enacted that the assessment upon the various cities and towns should be based upon the respective taxable valuations of property, to meet the interest and sinking-fund requirements for the sewer loan; and upon the respective populations of the several cities and towns, for the purpose of meeting the maintenance and operation expenses. In case less than the whole area of any city or

town uses the system, such apportionment is based upon the population of the areas using the system.

For the purpose of assessing the cost of the waterworks, Boston, the largest unit in the district, formerly paid each year the same proportion of the total annual cost that its assessed valuation during the preceding year bore to the total valuation of all the cities and towns in the district, but any city or town which had not reached the capacity of its own system and was not using water from the Metropolitan supply was assessed on the basis of only one-sixth of its valuation. After deducting Boston's payment, the remainder of the annual cost was to be apportioned to the other cities and towns, one-third in proportion to their respective valuations, and two-thirds in proportion to their respective populations. It is evident that such a method of apportionment of expense would not tend to restrain waste of water.

Extravagant use and waste of water, which indicated an early need of providing a new source of supply, led in 1904 to a new method of assessment. The proportion for Boston was enlarged, and those cities and towns which had not reached the capacity of their own works and were not using the "Metropolitan Water" were assessed on the basis of one-fifth of their total valuation. The remainder was apportioned, one-third in proportion to valuation, and two-thirds in proportion to use of water during the preceding year. In the year 1907, because of the apprehension of the farmers in those portions of the state from which new supplies have been drawn, an act was passed compelling those cities and towns, which derived any portion of their water supplies from without their own limits, to install meters at the rate of 5 per cent per year until all services should be metered.

Under each of these methods of assessment, a large burden was placed upon the city of Boston, which had the greater density both of population and valuation. One reason for this, which may be worth remembering in the formation of similar districts, was that the Metropolitan Water Board, upon beginning its work, took over all the lands, reservoirs, pumping stations and other water supply works and property of the city of Boston, and paid for these a large sum of money.

Passaic method. The method of assessment for the building of the trunk sewers and outfall works for the Passaic Valley was not fixed in the act, which was passed March 18, 1907. An agreement, however, entered into between the Passaic Valley Sewerage Com-

mission and the 3 cities and 12 towns and boroughs comprising the district, did fix, on March 15, 1911, the apportionment of the expense and the method of making payments thereon.

The relative capacities required by the several municipalities were determined by the board of engineers. The cost of construction was then apportioned between the several municipalities, somewhat in proportion to these relative capacities, allowing, however, about a 50 per cent increase for the City of Newark, the largest place in the district. It was further agreed that the annual expense of maintenance and operation, and the administrative expenses of the commission, should be assessed upon the several municipalities in proportion to the amounts of sewage delivered by them into the main trunk, as determined by measuring devices to be maintained by the Commission.

Winnipeg Assessment. The Winnipeg Water Act provides that one-half of the amount required for interest on first cost, sinking-fund payment, and cost of maintenance and operation, shall be borne by the land included within the water district, and which may be supplied from the works. It is important to notice that it is land, exclusive of improvements. Certain lands held by the King, or for the use of the Dominion or Province, or by a municipality, or for public schools, hospitals, architectural, or horticultural societies, or burying grounds are excluded. A special board is created for the fixing of these assessments. The other half of the total annual cost is to be borne by the sale of water to municipalities and to individual consumers.

CONCLUSIONS

The organization of communities or municipalities for a joint water supply or any other public utility under any of these methods—annexation, extension of municipal jurisdiction, contracts between municipalities, county administration, private enterprise, or metropolitan districts—is no easy task. This was exemplified, as given previously, by General H. M. Chittenden in the organization of the Miami Conservancy District for flood protection in the vicinity of Dayton, Ohio. The organization requires individuals with untiring efforts and just points of view. Very often such public-spirited citizens are severely criticized, but they may have consolation in the fact that it is the person who does things that is criticized. Our beloved Ex-President, and world citizen, Theodore Roosevelt, at a banquet in Washington, D. C., of the Engineers that built the Panama Canal once said: "Gentlemen you have completed a great work, no doubt your reward will be an investigation."

WATER WORKS PRACTICE IN QUEBEC[1]

By Théo. J. Lafrenière[2]

The history of the early water-supplies in this Province shows the tendency of using gravity works; unhappily our larger centers, with the exception of the City of Quebec, are located in the valleys and at relatively great distances from our numerous lakes.

The City of Montreal was the first town to install a public water-supply. In 1800, with a population of 9000 inhabitants, the water was secured from shallow wells and four public wells which were inadequate. A company was formed with the object of supplying the city with abundant water, and a fifty-year franchise was granted to it. The water was obtained from springs, back of the Mount-Royal, and brought by gravity through 4-inch wooden pipes into two reservoirs, one in the east and the other in the west portion of the City.

This first attempt in the Province was not very successful. The source of supply proved to be unreliable and the frequent breaks in the pipe line soon brought the system into disrepute. The company could not repair the works and sold its franchise, at a loss, in 1819, to a new company, which abandoned the gravity system. A steam engine was erected to pump the St. Lawrence River water into wooden tanks, one of which was 97 feet above the level of the river. The wood pipes were replaced by iron pipes of 4-inch diameter.

This second company did not have more success than its predecessor. The rapid growth of the City, requiring ever increasing volumes of water, necessitated the formation of a third company, in 1830, which replaced the main conduit by 10-inch pipes and renovated the pumping machinery. Important extensions and improvements were made during the following years, so that in 1843, the distribution system had a length of 14 miles, and the pumps had a capacity of 93,000 gallons per twenty-four hours.

[1] Presented before the Canadian Section meeting, March 4, 1925.

[2] Chief Sanitary Engineer of the Provincial Bureau of Health, Montreal, Quebec.

About this time, the advisability of a municipal system began to be discussed, which led to the purchase of the works in 1845, for the sum of 50,000 pounds sterling. The City immediately extended the water intake, in order to obtain purer water. Two years later, a civic committee recommended that water-power be used to pump the water and that a large reservoir be constructed on the mountain. In 1849, a 3,000,000-gallon reservoir was erected on what is now St. Louis Square, additions were made to the distribution system, but the question of water power was considered impracticable.

A great fire which occurred in 1852 destroyed part of the system, and instead of reconstructing it along the old lines, the City asked Mr. Thos. C. Keefer to prepare a report on the matter. The engineer recommended a canal from the St. Lawrence River, above the Lachine Rapids, to a point near the present pumping station. The canal would serve the dual purpose of supplying the water-supply and the necessary power to raise the water into a large reservoir located on the mountain.

The report was adopted, and the works carried out. The hydraulic power was sufficient to pump more than 4,000,000 gallons of water per day into the McTavish reservoir which is still in service. In 1856, the City of Montreal had modern water works, and it was expected that the water problem had been solved satisfactorily. However, the facts did not agree with the expectations. During the winter months, frazil ice partially blocked the canal, and back water in the tail race reduced the available power, so that the City was threatened with a water famine. Various improvements were made from year to year, but the relief was really obtained only in 1868, when the first steam pump was installed. The water consumption had then reached 5,000,000 gallons per day, approximately 45 gallons per capita per day. Steam pumps were added as needed, until 1921, when they were replaced by electrically driven units.

The City of Quebec was the second town to install a public water supply. In 1847, with a population of 36,000 inhabitants, the water was obtained from shallow wells and also from the river, delivered into the various parts of the City, by more than 100 water-carriers doing a thriving business. However, in that year, the City was authorized by the Legislature to spend the necessary monies to construct a water works, and, in 1848, Mr. G. R. Baldwin, of Charlestown, was retained to report on the matter.

Mr. Baldwin studied the St. Charles River and the Montmorency River, and recommended the former. The project consisted in a dam on the river, a subsiding reservoir, a cast iron aqueduct and a large distributing reservoir located on the highest part of the City. The main pipe line had a length of 40,000 feet and a diameter of 18 inches. The distributing reservoir had a capacity of 10,000,000 gallons. The difference in elevation between the river and the high water line in the reservoir was 115 feet, and the aqueduct was calculated to supply 3,000,000 gallons of water per day.

It is interesting to note that the report is largely inspired by the practice then followed in England, although mentions are made of the works in New York and Philadelphia. The water consumption was fixed at 30 gallons per head per day, and the works estimated for a population of 100,000 inhabitants, which the city was supposed to reach in thirty years hence. The thickness of the pipe line was set at 1¼ inch, after the maximum thickness used in the country main that brings water to the City of Edinburg.

Fire calamities, as in Montreal, had induced the city authorities to install a good water-supply; however, the works were not built until 1854, and both reservoirs were omitted. The 18-inch pipe line is still in operation and after seventy years service, as set forth in a recent report of special Commission, its flow is 2,760,000 gallons per twenty-four hours.

Although the increase in the population of the city did not follow the previsions of the engineer, thirty years after the construction of the first pipe line, in 1884, a new main, 30 inches in diameter had to be laid. The population was only 65,000, but the water consumption was greater than estimated, and kept on increasing, requiring an additional 40-inch main in 1913, when the population was 100,000 inhabitants, a population which the 18-inch line was expected to supply.

The water consumption in Quebec city has now reached the minimum flow in the river, and a special commission, appointed in 1924 to report on the whole system, found that the water was used at the rate of 228 gallons per head per day, or seven times more than was anticipated in 1848. The commission recommends a large distributing reservoir, as in Mr. Baldwin's report, and if the city had then constructed the reservoir, it would have spared its inhabitants many inconveniences suffered during the numerous breaks that have occurred especially on the 40-inch pipe line.

The next system installed in the Province, according to the available statistics, is a small gravity supply derived from springs and constructed in 1870. This supply, due to private enterprise is still in existence to-day, and iron pipes were used for the distribution.

In 1870, three years after the Confederation, the Legislature of this Province enacted the Municipal Code, a set of laws giving to the municipalities the necessary powers to pass regulations concerning health matters, and in particular to construct water and sewerage works.

The City of Sorel is one of the first towns to use the powers thus granted, and in 1872, a water system was installed. Steam pumps were constructed to force the Richelieu River water into the distribution system, and these pumps are still kept in good working condition, although modern pumping machinery is now used. These pumps rendered a great service a few years ago, during a fire which threatened the whole town with destruction.

From 1870 to 1880, fourteen water-works were constructed. During the following decade, 21 new systems were installed, and from 1890 to 1900, 47 more works were built. According to the available statistics, 80 other towns would have been provided with public water-supplies during the period extending from 1900 to 1910. These figures are not complete, as many small works were installed, without being recorded. It is estimated at the present time, that there are about 400 water-works in the Province, half of them being very small, and that the total population thus served is approximately 1,500,000 people.

The first works were generally installed by the larger towns, and the near-by rivers were used as a source of supply. In the smaller municipalities, especially where springs were available at a short distance, and at a sufficient elevation to allow a gravity supply, the works were generally constructed by private corporations. In such cases, the pipe lines were usually large enough to satisfy the domestic requirements of the towns, but too small to offer any fire protection. The result of this practice has been that the municipalities have been forced to buy the systems, after disastrous fires, and to build them anew, in order to meet the public needs of the town.

Rivers have been largely used as a source of supply, because the underground supplies have often proven unreliable. The springs

used have a rather limited yield. Deep wells have given highly mineralized water, unfit for domestic use. However, in a small section of the Province, sandstone can be reached at a reasonable depth and should supply satisfactory water.

Our large rivers offered for a time fairly pure waters. But with the increase in population and the introduction of sewerage systems in a large number of communities, the water became contaminated. The first purification works were installed after typhoid epidemics had shown the danger of using river waters without treatment. Previous to 1910, there were four pressure filters plants in the province. The first modern filtration plants were installed in 1911 and 1912, and today, there are 34 towns supplied with filtered river water. The first chlorination plant was installed in January, 1910, by the Montreal, Water and Power Company, and in February of the same year, the City of Montreal had its own plant in operation. The hypochlorite of lime was used at both of those plants, which served as models for other installations. From 1917, the hypochlorite plants have been gradually replaced by liquid chlorine apparatuses, and, at present, 19 towns are protected against water-borne diseases by chlorination only. Chlorine disinfection is used in all of the filtration plants, as an added measure of safety

These purification works have greatly reduced the typhoid death rate of this province, and it is very encouraging to note that municipal authorities realize better now the importance of a pure water-supply. Compulsory measures had to be taken in the past, to obtain the required improvements; three towns at the present time, have, plans in preparation for filtration works to be installed next summer, and the decision was taken without any compelling action from the Provincial Health authorities.

Our filtration plants have given good results, even when treating very soft waters; in such cases, frequent washings are required to prevent the passage of hydrate. In the majority of the plants, the high service pumps have a connection on the raw water line, for emergency use in case of bad fires. This practice is a dangerous one, but it is considered by several engineers as a necessary evil, owing to the high cost of filtration works. The capacity of the plants is determined by the amount of water necessary to meet the demand of ordinary fires, so as to reduce to a minimum the necessity of using the raw water connection. It must be remembered that

most of our plants are small and, consequently, the quantity of water pumped during a fire is much greater than the ordinary requirements.

The chlorination of water was not very successful at the start in the smaller towns. Decided improvements were noted in the results with the advent of liquid chlorine, but even these apparatuses were often out of order. The operators are now more familiar with the chlorinators and a good sterilization of the water is obtained; where results are not satisfactory, the fault is generally with the operation. However, all our rivers are turbid at times, and chlorination is then less effective. The treatment is considered in the Province as an emergency measure, pending the construction of filtration works, and as an added measure of safety in connection with filtration. All filtration plants have a chlorination apparatus.

In concluding, I may add that the usual practice is followed in pumping plants equipment. Electrically driven machinery is generally used, with steam pumps or gasoline motors as stand-by equipment.

A NOVEL COOLING POND

By E. J. Rowe[1]

In designing the present filtration plant for Wellsville, N. Y., it was decided to use an uncovered sedimentation basin. It was thought that the disadvantages of removing the ice would be less than the advantages of an open type basin.

Three winter seasons' experience with ice in this basin has shown that it was necessary to remove the ice at least three times during a season, requiring the labor of four to six men about a day for each removal. The dimensions of this basin are 44 by 22 feet.

During the spring of 1924, while designing the foundation and cooling water piping layout for a 500 kw. steam turbine generating unit, to be installed in the electric light plant operated in conjunction with the pumping plant, the writer concluded that he had had all the experience with ice removal necessary to complete his education along this line.

In laying out the circulating water piping it was decided to use the heat absorbed by the water from the steam to raise the temperature of the untreated water being pumped into the sedimentation basin. This meant using the suction well of the filter plant as a cooling pond, but without the usual expenditure of power necessary to secure elevation or pressure at the nozzles. This suction well is about 10 feet in diameter by 15 feet in depth and fed by gravity through a 16-inch wood stave pipe line from an intake located about a mile upstream in the Genesee River.

The use of the so-called "waterworks" type of condenser was considered, but owing to difficulties in design of the turbine foundation it was thought best to use the standard type small tube surface condenser. Another factor that had to be taken into consideration was that of a varying load on the turbine which made it necessary to vary the amount of cooling water to maintain as high temperature as possible of the condensate.

The filter plant is operated at a normal rate of one million gallons

[1] Superintendent, Water and Light Department, Wellsville, N. Y.

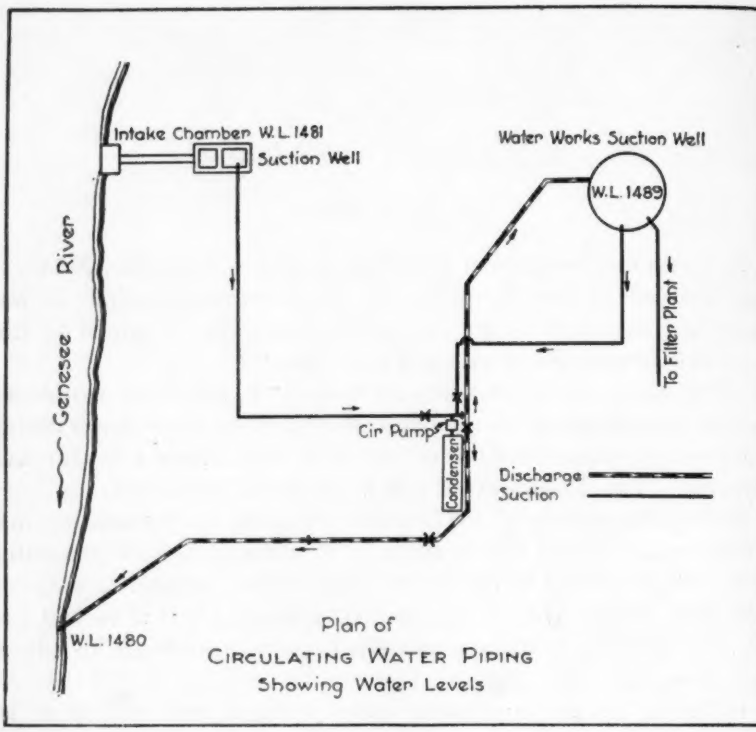
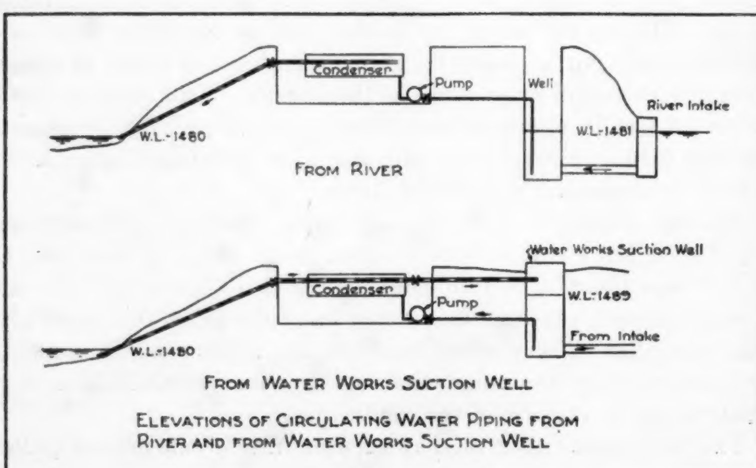


Fig. 1



Figs. 2 and 3

per day, or approximately 750 gallons per minute, and about twelve hours per day. The required amount of circulating or cooling water for the condenser varies, depending upon the load on the turbine, from 500 to 1000 gallons per minute.

During the winter season 1923–1924 nearly 6 feet of ice were removed from the sedimentation basin. On three occasions it was necessary to remove ice having a thickness of approximately 2 feet. The writer did not have the time to record the number of services up to and including 2-inch that were frozen that winter. During the last winter season, 1924–1925, no ice formed in the basin and no service was frozen.

The value of operating under these conditions has been reflected in the records of operation of the filter plant, much better results being obtained than was possible during previous winter seasons. The more remarkable and important effect has been that of reducing the tastes and odors resulting from applying chlorine to a water containing some phenolic compound.

The sketches used to illustrate this particular layout are practically self-explanatory. Figure 1 shows the complete outline of cooling water piping, both suction and discharge. Attention is called to the fact that it is a dual system.

An elevation or section drawing of the piping, etc., when recirculating the cooling water through the filter plant suction well, is shown in figure 2.

Figure 3 illustrates the piping layout used during the warmer seasons and during such periods as the filter plant is not in operation.

The hourly power requirements of the auxiliaries are less than 2 per cent of the capacity of the main unit, yet it would be very difficult to translate the advantages of this layout into terms of dollars and cents.

The advantages may be briefly summarized as follows:

Improvement in filter operation
Preventing ice formation in sedimentation basin
Reduction in number of frozen services
Control of temperature of condensate from condenser
Low power requirements

The use of a waterworks condenser would have increased construction costs and prevented control of temperature of condensate, as the water required for the filter plant is a constant quantity.

WHEN ARE ELECTRICALLY OPERATED PUMPS ECONOMICAL[1]

By F. S. McClintock[2]

A number of recent papers in the proceedings of the American Water Works Association have been devoted to various phases of the general question of the most economical type of drive for water works service. Practically all contain the statement that no general rule can be given and that each station must be considered as an individual problem. This is perhaps especially true of the smaller capacity plants where operating conditions vary most widely. As I believe that here you are more interested in installations of moderate capacities and heads such as may be generally met with in this neighborhood, I have tried in what follows to limit the discussion to what may be classed as moderate sized plants, say for example main units up to 250 b.h.p. and heads around 150 to 200 feet. Somewhat similar arguments may be applied to cases involving the very largest units, but other factors then enter which need not be discussed here.

The papers above referred to have given actual installation and operating costs of various types of equipment, and it did not seem desirable to try to parallel them by attempting to present any general cost figures. I should merely like to call attention to certain points in connection with electric driven units which should be considered, if this type is to make a satisfactory showing. It might be well, therefore, to repeat at the start that no general rule can be given which will determine when motor operated pumps are economical in water works service. Pumping capacities and heads, fuel and electric costs and local operating conditions vary so widely that the only satisfactory way to decide each case is by a careful trial calculation of costs on paper.

The type of electric pump for water works service under conditions existing in this territory is generally the direct connected motor

[1] Presented before the Indiana Section meeting, January 23, 1925.

[2] Chief Engineer, Dravo-Doyle Co., Pittsburgh, Pa.

driven centrifugal. Triplex or other direct acting motor driven units have their field in stations requiring small capacities and high heads, but for this region their use is so limited that I will confine further discussion to the direct connected centrifugal pump.

Ten to fifteen years ago three questions about reliability of electric drive were frequently raised: (1) is the type of unit, that is, motor driven centrifugal, reliable; (2) is the power supply, generally from some public service company, dependable; (3) if I dismantle my plant what assurance have I that the power company will not squeeze me on the rates; that is, is the power price reliable? Ten additional years' experience and innumerable installations have answered the first objection; serious outages on modern power systems are becoming fewer and fewer, especially as the systems are becoming interlocked in so called giant power circuits; and commission control and published rate schedules have largely dissipated the last objection.

The electrification question generally comes before the superintendent or owner of a water plant when some elaborate repairs or replacements are involved to an existing steam plant; his pumps are worn out, or more frequently, his boilers are beyond repair. He is then required to give careful thought to what can be done by electrification. On one side must be set past operating costs with steam, which are known, improved by such economies as can be reasonably expected of new apparatus; and he must consider the investment involved for new equipment. As against these are the unknown operating costs with electric power and its investment charges. It is fortunately possible to estimate with considerable accuracy what electric operating power costs will be, if the pumping demand is known or can be predicted. There are practically no accessories required by an electric pumping installation and usually the entire power bill is determined by the main unit. There is no necessity of allowance for coal under banked boilers, steam losses by condensation, steam required by boiler feed pumps and other auxiliaries, and similar items which so complicate an estimate for a steam installation. Usually the only auxiliary involved in an electric station is a priming pump of some sort. Therefore, given some estimate of the pumping demand and a power schedule, a close idea of the monthly power bill, which is by far the largest item of yearly expense, can be obtained.

For any given conditions of head and capacity, the pump manufacturers will furnish figures of first cost and power consumption.

The power required depends on the motor and pump efficiencies and it may be asked what allowance should be made for falling off in efficiency due to wear, in computing expected power bills for future years. The motor efficiency is generally accepted as constant. The pump efficiency losses will vary and may be considerable when handling sandy or muddy water. With the average water works, however, the main unit, where nearly all the power is used, handles clean water only, and in this service the loss in efficiency in a properly designed pump is very slow. I have seen pump wearing rings after four years' service with the tool marks fresh on them; published tests of the large motor pumps at Minneapolis, where careful power and capacity readings were regularly taken, show no measurable loss in efficiency after four years continuous service averaging about twenty hours per day, and without replacements or repairs to any interior parts of the machine. In some cases power bill estimates are made on the original stated efficiency without any allowance for deterioration on the ground that no greater error is involved than would be found in variations in slip or leakage losses in a steam unit; in any case one or two per cent allowance should be ample, for when the losses are much greater it generally pays to bring the unit back to its original performance by installation of new wearing rings.

Two general results of a trial balance may be expected; the first cost of electrical equipment will be far below that of equivalent capacity using any other drive; and the expected monthly electric power bill will be larger than the monthly coal bill. The final judgment must of course total these and other factors into a final yearly operating cost for comparison.

In figuring electric power costs and in the selection of units, if the installation is finally made, I would suggest the consideration of some features of modern power schedules which are important, if best results are to be obtained, especially demand charges and power factor.

It is better not to install motor units of much larger capacity than necessary. No one wishes to disregard expected growth and increased demand and install units only just large enough for present requirements; but it must be remembered that the power company will charge considerably more for pumping a million gallons in eight hours than for the same amount in twelve hours. Do not, therefore, put in pumps larger than that for which you can reasonably expect use. In the very common case of a small storage capacity and vary-

ing seasonal demand, consideration should be given to combinations of various sizes of units to meet varying requirements; for example, a 1, 1½ and 2 m.g.d. unit instead of three 1½ m.g.d. units. A further very desirable way of providing for future expansion is to buy pumps and motors large enough for expected future conditions, and have the pumps equipped with impellers of smaller capacity and, therefore, smaller horsepower demand for present conditions. Most power companies base their demand charge on the actual k.w. demand as read from a demand meter and not on the motor size, and a lower current rate can be secured until the pumping demand increases to the limit of the smaller impeller when the unit capacity can be increased to the maximum by the installation of a new impeller at a very reasonable expense.

Few people appreciate how wide a range is available in this way due to the flexible nature of the centrifugal pump. For instance, out of a given 4-inch single stage pump case, it is possible to develop efficiently any capacity from 300 g.p.m. to about 650 g.p.m. by changing impellers; similarly with an 8-inch pump a range of from 1400 g.p.m. to 2400 g.p.m. is possible. The cost of the pump itself is ordinarily unchanged within this range; therefore, it is possible, without adding to the cost of the pump end of the unit, to install a machine for a present capacity of 2 m.g.d. and an ultimate capacity of 3½ m.g.d. Ordinarily it pays to install at the start a motor of sufficient size for the ultimate capacity, but if desired or if required by the power company, a smaller motor can be installed at first and provision made on the bedplate for ultimate changes.

As an example of the effect of an oversize unit, an estimate made recently for a small water plant may be of interest. They had a present demand of 850,000 g.p.d. at about 175 feet and wished to consider a 2 m.g.d. or 3 m.g.d. unit, running part time. They had reservoir capacity to pump the required amount and close down for the balance of the day. If a 3 m.g.d. unit was installed the daily pumping could be done in 6⅔ hours and the load would be approximately 100 k.w., or a total of 667 k.w. hours per day. The monthly power would be 20,000 k.w. hours. If a 2 m.g.d. unit was installed the unit would run 10 hours per day, the load would be 66.7 k.w., the daily power would be 667 k.w. hours; the monthly power would be 20,000 k.w. hours as before. On account of the smaller demand charge the monthly power bill worked out at $498.50 for the 3 m.g.d. unit and $405.20 for the 2 m.g.d. unit, although the same amount of

water was pumped and the k.w. hours per month were identical. This represented a saving of 19 per cent in favor of the smaller capacity and would have paid for a 2 m.g. impeller for the 3 m.g. unit in about two months.

This sort of thing can, of course, be carried to extremes, and it is not intended to suggest that a series of impellers be carried for installations as seasonal demand varies, but in cases where it is found that the required pumping is being obtained in less than convenient operating shifts, a very appreciable saving can often be made by pumping at a lower rate. On the other hand the necessity for additional attendance may wipe out the power saving. "Off peak current rates" may make it desirable to pump the daily supply in a few hours, but my own experience has been that it is rarely possible to take advantage of this type of current supply.

Regarding power factor, it is only recently that any change was desirable from the squirrel cage motor. This type is perfectly satisfactory and was practically standard for motor driven centrifugal pumps. If properly loaded it will give a power factor of 0.89 to 0.95, and even at half load, as might be involved by a small impeller for present conditions, the power factor should not fall below 0.85 to 0.87. Recently the power companies have been offering discounts for improved power factors. These are expressed in various ways but generally run from 1 to 5 per cent, if the station power factor is kept at unity. Under these circumstances synchronous motors with direct connected exciters frequently repay the higher first cost. This type of motor is, of course, more complicated than the squirrel cage, but the starting apparatus has been much simplified lately until it is practically no more difficult to handle than the squirrel cage motor; in fact for the smaller sizes the same type of starter is used. Synchronous motors have been developed and are regularly built with sufficient starting and pull in torque to start a primed centrifugal pump. It is generally desirable, however, to start with the discharge valve closed bringing the unit to speed before opening the valve to the line. Under these conditions the horsepower and torque involved in starting is reduced to about 40 per cent of that at full discharge.

Synchronous motors are not made in small powers for pump speeds. In general, present experience indicates that they rarely are warranted in sizes below 75 to 100 h.p., on account of the disproportionate increase in cost due to the separate exciter. They add from 50 to 100 per cent to the cost of the motor, as compared to a squirrel

cage type, the greater increase applying to the smaller sizes; this corresponds to 15 to 50 per cent increase in the price of the complete unit. In plants where the installation consist of small powered low service or raw water pumps with larger powered high service units, synchronous motors on the high service can be run at slightly leading power factors to compensate for the smaller squirrel cage motors on the low service, and a station power factor of unity obtained. It is now possible to obtain full automatic starters for these synchronous motors, either push-button or float controlled, and there are practically no conditions to which they cannot be successfully applied where the power discount warrants the expense.

A point in connection with figuring operating costs, aside from the question of power bills, is the matter of attendance required. Simplicity and lack of constant attendance on a motor driven centrifugal are not always taken advantage of as they might be, and in figuring prospective operating costs consideration should be given to whether labor and attendance charges as involved with steam equipment cannot be materially reduced. Cases could be cited where the pump house is locked up all day, to be visited morning and evening for general inspection, filling of oil wells, etc. The care of the pump is frequently so small an item that it can be combined with other work about the filter plant or elsewhere. This is often one of the greatest savings.

Especially where a system has limited storage in standpipe or reservoir, sole dependence cannot be put on a single power line to the station, no matter how many generating stations are tied into the circuit. The question of standby or emergency power sources has been conveniently solved by high speed gasoline engines of the motor boat type direct connected to the centrifugal pumps. This meets the requirements of the Underwriters as an emergency power supply, has no standby power charges, can be run by anyone reasonably familiar with automobiles, requires no warming up, is ready for immediate service and involves no great initial expense. Dual drive units, that is a pump with a motor on one end and an engine on the other with a clutch between the engine and the pump, are most common. A separate gasoline engine driven pump is sometimes desirable especially when high pressure is required for fire service. Where a number of small motors scattered around a plant all must be kept in operation, it may be preferable to install a single gasoline engine driven generator of sufficient size to run all essential motors instead of attempting alternate drives for such small machines.

An interesting application of gasolene drive is in its use for avoiding peak loads which would increase the monthly power demand charges. Some account of this may be found in a paper by W. S. Lea in THIS JOURNAL, October, 1924. Occasional use of a separate gasolene driven unit for a few hours prevented their starting a second motor driven machine which would have increased the demand charge for the entire month. In another town they were required to put on a booster pump and raise the pressure for fire service, and this had to be done in case of each alarm regardless of whether any additional water was actually used or not. A single alarm increased their monthly power bill considerably, due solely to the increase in demand charge, until they met these emergencies by starting the gasolene driven unit which left their demand charge unaffected and cost them only the gasolene actually used. Modern engines of this type use from $\frac{1}{8}$ to $\frac{1}{10}$ of a gallon of gasolene per horse power hour; it is not necessary to carry a large stored supply, on account of the number of sources available. The engines themselves will cost from $30 to $50 per horse power.

The motor driven pump is at its greatest disadvantage in cases where the pumpage is direct to the mains without standpipe or reservoir. This condition can actually be met either by using a slip ring motor with about 10 to 15 per cent speed variation or by constant speed units allowing the pressure to vary slightly with the demand. Centrifugal pumps may be designed with flat characteristics so that the rise in pressure between full capacity and no delivery is only about 10 per cent. The pressure change in the line under varying demands will then not be so serious; but it is very wasteful of power and it will probably be necessary in figuring approximate power costs to take the full pump horse power regardless of the variation in water demand. Different sizes of units are particularly important here to meet varying demand. No arrangement of motor pumps has been devised which can approach a steam driven unit as regards flexibility in installations of this kind, and the few actual electric plants that I know of have in each case had special circumstances which dictated the type.

When a city light plant is combined with a pumping plant, it is harder to show a case for motor pumps; it may still pay to use motor pumps, taking current from the town supply, especially for small units, such as raw water pumps which are inherently uneconomical in small sizes in steam drives.

All of this discussion of operating costs has left out of consideration one of the advantages of motor pumps and a factor which on equal or slightly unfavorable cost bases would still sway the decision in favor of motor pumps. Unless you are familiar with motorized plants it is hard to appreciate the simplicity and absence of constant attention involved. Recurrent epidemics of coal shortages and progressive contamination of boiler feed water with the more rapid destruction of boilers have placed heavy worries on the shoulders of small plant operators who must keep continuous service. It is worth something to pass these troubles on to a larger organization such as the central power company, whose business it is to cope with them and who can afford to make elaborate preparations to guard against them. If you add the simplification of the operating labor question, this factor has frequently determined the type when operating costs alone would not have justified a change.

WATER TREATMENT AND SOFTENING PLANT AT SPRINGFIELD, ILLINOIS[1]

By C. S. Timanus[2]

CHARACTER OF ILLINOIS WATER SUPPLIES

Illinois, in common with most of the central and western states, is notable for its hard waters. With the exception of supplies taken from Lake Michigan, all others of the state may be termed hard. Those from the rivers vary over wide ranges, of course, depending on the flow of the stream, while the well supplies are universally classed as extremely hard. Of 338 municipal well supplies reported by the State Water Survey, 300 have a hardness of over 300 parts per million. Of the well waters, the rock wells of the northern part of the state supply water much harder than the shallow or drift wells which are found generally in the southern part of the State.

WATER SUPPLY OF SPRINGFIELD

The water supply at Springfield is taken from drift wells and infiltration galleries drawing from the shallow sands of the Sangamon River valley north of the city. This water exhibits the same characteristics as the other shallow ground water supplies of the state, having a hardness of 280 to 300 parts per million. Of this hardness, about 60 per cent is due to calcium bicarbonate, 25 per cent to magnesium bicarbonate and 15 per cent to magnesium sulphate. Laboratory tests indicate that the water is very easy to soften.

In addition to the high mineral content resulting in hardness the water also contains iron in appreciable amounts, averaging about two parts per million. This iron is present in the form of ferrous hydroxide when the water first comes from the wells but on being exposed to the air is oxidized, resulting in a reddish brown precipitate and a slight turbidity.

[1] Presented before the joint meeting of the Illinois, Iowa and Wisconsin Sections, March 18, 1925.

[2] With Burns and McDonnell, Consulting Engineers, Kansas City, Mo.

The operation of an experimental plant at Springfield indicated that, while a part of the iron could be precipitated by the simple process of aeration and sedimentation, the colloidal or finely divided state of the remainder demanded further treatment.

The early studies of the engineers indicated the advisability of a plant designed to remove only the iron and special types of iron removal plants similar to coke filters or Rieslers were considered. However, the ease with which the water could be softened influenced their recommendation for an iron removal and softening plant, using coagulation, sedimentation and filtration.

Several years elapsed after these first studies. In the mean time the rapid growth in demand indicated that the present well supply will in the near future reach its economical limit of development. In this event the Sangamon River water can be used and will probably become the principal source of supply.

The Sangamon River water is much softer than the well water, but very turbid and poor in sanitary quality. Samples indicate a range of hardness from 137 to 286 parts per million and a total mineral content, varying from 193 parts per million to 319 parts per million.

The sanitary quality of the river water is gradually being improved by the construction of sewage disposal plants by the principal towns along the river which have heretofore been the source of contamination. With the completion of Springfield's new sanitary program, the sanitary quality of the river water will be much further improved.

BASIS OF DESIGN

In view of the present source of supply, the wells and galleries and of the possible future source, the Sangamon River, the new treatment plant has been designed with the idea of removing both the iron and hardness from the underground water and the turbidity and hardness from the river water.

Inasmuch as the sulphate or permanent hardness is only 15 per cent of the total hardness of the well water, no attempt has been made to remove the magnesium sulphate. It is planned, by lime treatment, however, to remove practically all the hardness due to calcium bicarbonate and part of that due to magnesium bicarbonate, giving a final product with a hardness between 100 and 125 parts per million. In this process, the iron will also be eliminated. Alum will be added wherever necessary to aid in coagulation.

CHARACTER OF RIVER WATER

The river water can be treated in much the same way. Its lower degree of hardness, however, will require less lime, but the turbidity will probably call for the use of more alum.

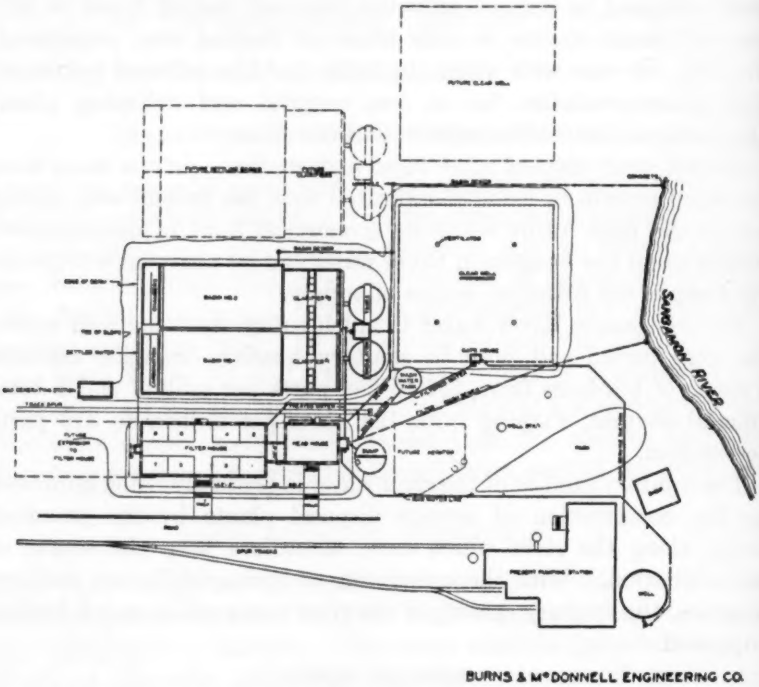


FIG. 1. GENERAL PLAN OF WATER TREATMENT PLANT SPRINGFIELD, ILL.

COAGULATION TANKS

The water will be pumped directly from the wells or river to the new treatment plant where it will be received in the chemical dosing well. The lime and alum will be applied here and the water will then flow to the coagulation tanks. There are two of these tanks of the mechanical agitation type. The period of retention is forty minutes during which time the water will be thoroughly agitated by motor driven paddles, revolving at a rate of one-half a revolution per minute. Eighty to ninety per cent of the softening will be accomplished in these tanks, depending mainly upon the temperature of the water.

CLARIFIERS

From the coagulation tanks the water will next pass to the clarifiers. These basins are each 63 feet square and 15 feet deep at the center, giving a retention period of one hour and forty minutes. An unusual feature of their construction is the use of concrete arches to support the clarifier mechanism.

Over 90 per cent of the settleable solids will be deposited in these basins. The sludge will be removed by two Dorrco diaphragm pumps, arranged to discharge into the sewer or to return the sludge by short passages to the coagulation tanks where unspent lime may be used. The pumps are housed in a small building nearby, which also contains control valves and the motors driving the paddle mechanism of the coagulation tanks.

SETTLING BASINS

From the clarifiers, the water will flow to the settling basins. These basins provide further capacity for sedimentation and compensate for any unequal dosage of chemical or for change in effectiveness of chemicals due to change in the temperature of the water. There are two of these basins, each 70 by 135 feet by 12 feet deep, providing a theoretical detention period of three hours and fifty minutes.

CARBONATION CHAMBERS

Water will be taken off the settling basins over skimming weirs and conducted to the carbonation chambers. These chambers are also in duplicate and are so baffled that the water will travel at a very low velocity, approximately 140 feet over a submerged grid system from which carbon dioxide gas will be discharged.

This treatment is intended to prevent the after formation of lime or carbonate deposits on the filter sand or in the water mains. When the water reaches the carbonation chambers, under the most favorable conditions, only about 90 to 95 per cent of the softening reaction has been completed. The carbon dioxide will be introduced to reverse this reaction and prevent its going to completion on the filter beds.

Carbon dioxide will be supplied from a small gas generating plant, equipped with a small gas producer burning coke. The gas will be passed through a scrubber and forced to the carbonation cham-

ber by means of a motor operated blower. The capacity of the generator will be 3500 pounds of CO_2 gas per day.

From the carbonation chambers, the water will be conducted to the filter house through a 42-inch cast iron pipe.

FILTERS

The filter house is a concrete brick structure 60 feet by 140 feet, housing eight 1½ million gallon filter units. The filters are arranged on each side of a central pipe gallery and are entirely within the building. Water will be distributed to the units from a central conduit located directly under the operating floor. The filters themselves are 29 feet by 21 feet and are designed to operate at a rate of two gallons per square foot per minute. Each filter is divided into two compartments by a central wash gullet under which is the effluent conduit. The filtering medium consists of 30 inches of sand and 18 inches of graded gravel. The under-drains are 3-inch perforated cast iron pipes. The rate-of-flow controllers are of the Venturi type with generous capacity and low loss-of-head.

The controllers will discharge into the clear well conduit located under the pipe gallery floor and leading to the clear well. The filters will be washed by a high velocity wash from an elevated tank. Wash water will be conducted from the filters through sewer conduits under the pipe gallery floor to the river. During high stages in the river, the wash water will be directed to an underground sump from which it will be pumped back into the chemical dosing well to pass through the plant again.

CLEAR WELL

The clear well is a novel feature of the plant. This basin has a capacity of 2 million gallons, is 180 feet square and 10 feet deep. Floor and roof are of heavy flat slab design and the entire structure is loaded with 8 feet of earth to overcome the buoyant effect of ground water during extreme high water stage in the river.

CHEMICAL PLANT

Special provision is made to handle the large quantities of chemicals required for the softening process.

At normal capacity 6 to 8 tons of quick lime will be required per day. At Springfield the use of quick lime offers a saving of about

$6.00 per ton over hydrated lime. The lime will be delivered in carload lots, crushed to 1 inch and smaller in size. Unloading will be accomplished by means of a power shovel bucket elevator and screw conveyor or possibly by an air conveyor which will discharge into the storage bin. There are three of these bins, each with a capacity of two carloads.

Directly under each bin is a hopper scale of 1000 pounds' capacity. This scale is fitted with a revolving bucket which will discharge 2 pounds of lime per revolution, into the slaking tank, where hot water will be added and the mixture thoroughly stirred by revolving rakes until the lime is slaked. The slakers are arranged so that they may be operated either on the fill-and-draw plan or continuously. Under each slaker is a horizontal solution tank which will receive the discharge from the slaking tank and in which the milk of lime will be brought to a standard solution. These tanks are equipped with paddles revolving about a horizontal axis. This type of tank is designed to prevent the stratification of the milk of lime solution.

Each lime handling unit, consisting of scale, slaking tank and solution tank, has its own individual motor for power. All valves, levers and switches controlling the unit are grouped together for convenient operation.

From the solution tanks, the milk of lime will be lifted by means of steam operated ejectors to the lime feeders located over the dosing well. These feeders are convenient to the raw water meter, thus enabling the operator to proportion easily the lime feed to the amount of raw water pumped.

Alum will be stored on the second floor of the head house and will be fed by means of dry feed machines into the dosing well. A small chlorine room equipped with exhaust fan is provided in the basement of the head house. Chlorine gas will be fed by means of a Wallace and Tiernan Type MSV Chlorinator, which is located conveniently on the first floor.

In planning the plant layout, the engineers have provided for future extensions which will double the present capacity of the plant. These extensions can be made without interfering whatever with the operation of the part now under construction. Particular attention has also been given to the operating centers of the plant. The laboratory is located in the head house convenient to the chemical preparation and dosing apparatus. An office is also provided to serve the chemist and the chief engineer.

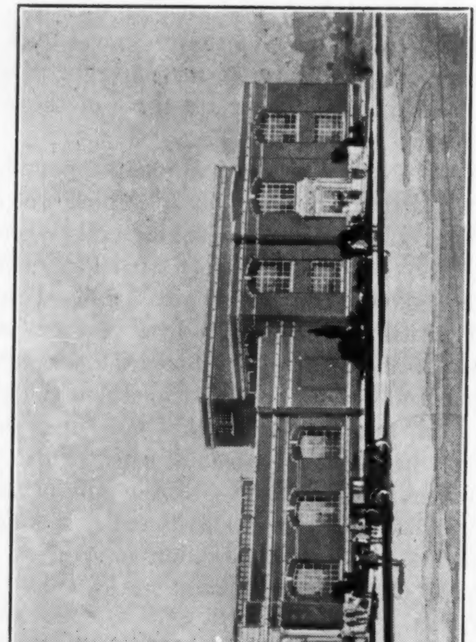


FIG. 2. ARCHITECTS' PERSPECTIVE OF FILTER HOUSE AND HEAD HOUSE, SPRINGFIELD, ILL.

ARCHITECTURAL FEATURES

Architectural features of the buildings were given careful consideration. All buildings are substantial, fireproof structures of concrete and brick with cement tile roofs and cut stone trim. The exterior treatment of buildings is designed to give a pleasing appearance without in any way detracting from the utilitarian character of the structures. The interior of the filter house follows out the same idea. Interior walls are of a good grade of face brick. Floors are terrazzo. All filter beds are inclosed with ornamental iron railing. Filter operating tables are marble, with mahogany doors and nickle trimmings.

In the head house, the entrance lobby, office and laboratory have terrazzo floors and sand finish plastered walls and ceilings. Special provisions have been made to confine the lime dust during operation of apparatus. The chemical preparation room is separated from other parts of the head house by double dust tight doors.

The main buildings are set well back from the roadway and afford opportunity for beautification of lawns and surrounding grounds.

The special features of the design which warrant emphasis are:

1. The plant can be very easily enlarged to twice its present capacity.
2. All basins, tanks, and operating mechanism are in duplicate.
3. Mechanical agitation is employed in the coagulation process.
4. Clarifiers are used to keep sedimentation 100 per cent efficient.
5. Carbonation is provided to prevent after-deposit of lime.
6. Ample clear well storage is incorporated.
7. Lime handling equipment is designed to use quick lime at a considerable saving over hydrated lime.
8. Architectural and landscape features are carefully considered.

The city officials of Springfield, realizing that the problems of treating water at Springfield are similar to those found in many other parts of Illinois, have sought to provide a plant that would serve as a model for other municipalities of the State.

STORAGE—A SOLUTION OF THE FIRE RESERVE PROBLEM[1]

By Charles W. Parsons[2]

Many cities have a well designed water supply system which provides a sufficient amount of pure water at a satisfactory pressure for all domestic and industrial purposes. In these same cities an occasional large fire taxes these otherwise satisfactory water facilities to their limit and records show that many large fires, which have resulted in great property waste and sometimes in loss of human life, could have been checked before reaching conflagration proportions, if a sufficient volume of water had been available. Even in cities where conflagrations have been prevented by the efficient use of the available water and the fire fighting apparatus, the lack of a proper number of fire streams for handling a fire of long duration, which would be possible in the existing buildings, is an ever present hazard to the lives and property of the citizens and to the future of the city. This potential hazard is also reflected in the cost of insurance throughout the city.

Engineering studies of the water supply systems in many cities of this state and of the country indicate that in all too many instances the various parts of those systems have been designed and improved to provide a supply that would be satisfactory for domestic purposes. Whatever fire protection could be furnished by this equipment was deemed the best that the city could afford. In many of these cities, and especially in the smaller ones, a comparatively small additional investment and sometimes merely a different design of the plant would provide a much more adequate and reliable water supply for effectively fighting the larger fires. Consulting engineers and water superintendents have a real opportunity to render valuable service to their cities by giving special attention to the fire protection features of the water supply systems which they install and enlarge. Of the

[1] Presented before the joint sessions of the Illinois, Iowa and Wisconsin Sections, March 17, 1925.

[2] Engineer, Illinois Inspection Bureau, Chicago, Ill.

many parts of a water supply system which should be given careful consideration, it is the purpose of this paper to deal with only one, namely: storage.

In order to determine the amount of storage that should be provided in connection with any particular water system, several factors must be known. The amount of water which is necessary to handle large fires in various cities has been given much study. The experiences of the most successful practical fire fighters, the opinions of the foremost fire protection engineers and the results of innumerable tests and actual fires have been condensed into definite figures in the form of the equation and tables compiled by the National Board of Fire Underwriters. These data are familiar, or should be familiar, to all consulting engineers and water superintendents. It is the basis for the requirements specified for cities of various sizes in the "Standard Schedule for Grading Cities and Towns," which is used as the basis for the fire insurance classification for all cities in this state and in most other states. As these data have frequently been published they will not be given in detail here. The quantities required for the proper protection of the closely built districts of various cities have been found to be practically proportional to the populations of those cities. For example, a city of 40,000 population requires a fire flow of 6000 gallons per minute, one of 10,000 population requires 3000 gallons per minute and a small city of 1000 people requires 1000 gallons per minute.

These quantities seem large in comparison with the average domestic consumption in cities of those sizes. This becomes particularly pronounced as we consider the smaller cities. The reason is apparent. Even in most villages of 1000 population there are two or more blocks of closely built mercantile buildings of generally inferior construction including numerous frame buildings and sheds and in many cases these are exposed by a lumber yard or a group of large area buildings. A serious fire in such a location has the possibility and often the probability of a most serious calamity to the community. When efficiently handled, three fire streams of 250 gallons per minute each are scarcely sufficient to control such a fire. With an allowance of 50 per cent additional for waste from broken hose lines and services due to falling walls and other typical conditions incidental to a large fire, this minimum quantity will be in excess of the 1000 gallons per minute specified. In the more extensive business and manufacturing districts of larger cities a correspondingly larger number of effective fire streams are necessary.

The contrast between this quantity needed for effective fire fighting and that supplied for domestic consumption is especially marked in the smaller cities and villages. Many municipalities of 1000 population for example, use less than 40,000 gallons per day or an average of 28 gallons per minute in contrast to this 1000 gallons per minute necessary to handle properly a large fire. Thus the requirements for fire protection are about 35 times those for domestic consumption. With the increasing size of the cities, the difference is less marked, although a factor of paramount importance in the design of the water supply system and in the reliability of the protection of human life and property from fire. Many cities of 10,000 population have an average domestic consumption of less than 800,000 gallons per day or 550 gallons per minute, while a fire flow of 3000 g.p.m. is required for the corresponding mercantile district. This is over 5 times the domestic requirements. This difference decreases more or less uniformly to approximately 2½ times the domestic for an average city of 40,000 population, and becomes equal to the average consumption for one of 100,000 population. Of course, in the still larger manufacturing and distributing centers of our country, the fire requirements are only a fraction of the enormous quantities normally supplied to the city and the problem becomes an entirely different one. We shall consider here only the smaller cities where this difference is especially marked and where it is so often permitted to become a serious obstacle, or at least an excuse, against providing even a fair quantity of water for fighting serious fires.

The cost of improvements and operation are often financed by one of several methods which eventually are dependent entirely upon the revenue from domestic consumption. There is often no direct income from the fire protection service rendered to the community. Whether or not this is the most equitable method is beyond the scope of this paper. The result, however, is the natural one. The water supply system is designed and improved to perform economically and effectively the function for which the charges are made, namely: to provide sufficient pure, palatable water at satisfactory pressures for domestic consumption. A water works which furnishes this service uninterrupted is considered by the citizens as entirely satisfactory for the city's needs. This is especially true where the local fire fighters have been successful in stopping the fires in their incipiency, and the need of the larger quantities has not been forcefully brought home by a disastrous fire. The inability of such a system to

meet the greater demands of a big fire is too often unjustly charged to the failure of a water works operator to perform his duty. A water works designed to handle a certain consumption with an ample factor of safety naturally will make a pronounced failure when called upon to supply from 5 to 35 times as much for a period of several hours.

Where an ample and satisfactory supply is available at an advantageous location, the installation of a fire pump of sufficient capacity will completely solve this problem and will enable the domestic system to function admirably in the emergency of a big fire. The size and design of such a fire pump would depend upon the size of the city and the character of the water works. Pumps of 750, 1000 and 1500 g.p.m. have been popular for such installations. A stand-by fire pump of this character should be provided with a gasoline motor of suitable size and design. This would partially off-set the serious unreliability of depending entirely upon a single source of electric power for pump operation. Such an ideal water supply however is not often available.

In many cities of Illinois and other central western states there are only one or two available sources of municipal water supply: deep wells and surface streams. Wells are expensive to drill and the water in the majority of streams must be filtered before being safe for domestic use. In either of these cases the drilling of additional wells or the construction of sufficient filter capacity to provide this fire flow of several times the normal domestic load is usually a financial impossibility and unsound engineering practice. The one solution of this problem seems to be storage; above ground clear water storage both in case of a well supply and where filters are used. If this storage is ample and is located near the city, the reserve pumps can deliver the necessary quantities to the fire. If the storage and pumps are at some distance from the closely built sections of the city it will be necessary to provide adequate and reliable supply mains to these points. In some cases the source of supply is several miles from the city and the high cost of additional lines makes it much more economical to provide a storage reservoir and stand-by pumps at the city end of this supply line. Regardless of the local problems of the individual cities substantial storage and adequate reserve pumping capacity will practically always solve this problem of providing ample water to meet the demands of a serious fire. In so many of our mid-western cities where the supply is from deep wells or is filtered, the

cost of providing this storage will be surprisingly less than the cost of maintaining well or filter capacity of from 5 to 35 times that necessary for domestic requirements. Is there any better way of solving this most important problem?

A surprisingly large number of Illinois cities have failed to appreciate the great advantages of substantial storage. Many of these plants have such small storage capacities that the filters and wells cannot be operated on the best schedule and when a brief shut down is necessary for minor repairs the small storage is reduced to a dangerous minimum or entirely depleted and the service interrupted. Of 34 filter plants in cities of Illinois under 30,000 population, none have over 1,000,000 gallons clear water storage, only 7 have over 400,000 and the average is 308,000 gallons. The average storage provided at plants dependent upon deep well supply is often much less, frequently being as low as 100,000 gallons and sometimes being confined to such a small basin that the pump must be regularly operated with a partially closed discharge value in order to equal the well yield. Such practice is obviously both expensive and unreliable even for attempting to furnish an uninterrupted domestic supply. Such cities would be entirely at the mercy of any ordinary fire in case of even a brief interruption of the well supply. The same would be true at a filtration plant where the supply of raw water might be temporarily checked or slight difficulties develop in filter controls just at the critical stage of a fire. It is surprising and indeed startling to discover this condition in so many of the small water works of our state. No doubt this condition is equally prevalent in many other states. The encouraging part of the situation is the ease with which these plants can be made capable of furnishing reliable domestic service and even be improved sufficiently to handle adequately the large fire which is ever probable in that city. The cost of furnishing that service is within the reach of almost every community. It is one of the best paying investments that a city can make. Water superintendents have a real opportunity to serve their city by recommending and actually installing adequate storage. Designing engineers have perhaps even a greater opportunity to render their client a service by including in their designs for improvements and for new plants, sufficient storage capacity to provide uninterrupted domestic supply and adequate quantities for fire protection.

The proper storage capacity for a city of a certain size is readily determined. As previously mentioned, no storage whatever need be

provided where an adequate supply is readily available near the point of consumption, if sufficient pumping capacity is provided for the peak loads. The other extreme is the small city with but one or two deep wells, or maybe one or two filter units, of a total capacity very little in excess of the domestic consumption. While an additional well or filter should properly be provided and in fact as many such wells or filters as possible, the cost may be prohibitive. In such a case, sufficient storage should be provided so that the necessary fire flow may be furnished for the proper length of time. It has been found that this flow should be available for a period of ten hours, except in cities under 2500 population where a five-hour period is the minimum. The excess of the maximum domestic and fire flow rates over the rate of yield of the wells or filters, is the rate of flow which must be provided from the storage during the necessary period. As an illustration, a city of 1000 population requiring a fire flow of 1000 gallons per minute for a five-hour period has a domestic consumption of 40,000 gallons per day and a deep well yielding 200 gallons per minute. Only 172 g.p.m. is then available to provide the 1000 g.p.m. fire flow. The remaining 828 g.p.m. for five hours will be provided by a storage of 248,000 gallons. If a 200 g.p.m. pump is used for discharging into the mains, the installation of a 100,000 gallon elevated tank, a 150,000 gallon suction reservoir and a 500 g.p.m. reserve pump driven by a gasoline motor would provide the necessary supply for domstic consumption and fire flow. This substantial reserve would also make it possible to make ordinary repairs without interrupting the domestic supply. Larger cities would require correspondingly larger storage capacity depending upon the normal capacity of the wells or filters. In some plants in cities of from ten to twenty thousand, a storage of from 500,000 to 1,000,000 gallons and up would be necessary to provide the proper fire flow where the normal capacities were but slightly in excess of the average consumption. It might not be feasible in some cities to provide quite the total necessary fire flow, but a very large proportion of this amount can practically always be provided in this way at a cost very much below the benefit derived.

Elevated storage is always of greater value than suction storage as it is immediately available without additional pumping. If the full amount of necessary storage could be provided at a sufficient elevation to furnish adequate pressure, the need of reserve pumping units would be eliminated. Suitable main capacity should be provided

for the desired flow between this storage and the mercantile and manufacturing districts. In so many of the smaller mid-western cities the absence of hills limits this storage to the amount that can be feasibly provided by elevated tanks. A moderate amount of such storage is necessary for economical pumping. Substantial storage makes it possible in small cities to operate the pumps for convenient periods during the day and in larger cities enables the peak consumption demands to be met without use of additional pumping units. Where an electrically operated station is dependent upon an overload power line, this storage enables the pumps to be shut down for the short evening maximum load period which may mean a saving in power charges. The capacity and height of an elevated tank depend upon the conditions in the individual city being considered. The old style standpipe has been entirely superseded by the tank on structural steel supports, as high pipes of small diameter were little better than surge towers, as any moderate depletion of the storage would greatly reduce the pressure. Even the smallest municipalities should have a tank of at least 100,000 gallons capacity and the majority of cities will find one of 250,000 gallons capacity a convenient size for efficiently handling the peak loads and for providing sufficient reserve while making minor repairs on the pumping equipment. A tank should be sufficiently high to provide a good domestic pressure in all parts of the city. An average pressure of perhaps 60 pounds where buildings do not exceed two stories and perhaps 75 pounds for other moderate sized cities enables the fire department to handle the majority of fires without the use of pumping engines. Such engines are needed, however, in all large cities and in those smaller cities where normal pressures are low or where they are reduced below the necessary minimum by the friction loss in undersized arterial feeders and by a weak gridiron. If possible the elevated storage should be located on the side of the principal mercantile district away from the pumping station so that in case of a break in the supply main from the station this storage will be available in the district.

Sufficient suction storage should be on hand to provide that portion of the rate of flow necessary for domestic consumption and fire demands which is not available from the source of supply and elevated storage. A reinforced concrete reservoir with a cover of similar material seems to be the most feasible design. If the location of the pumping plant is a central one, which is advisable, land values will probably dictate that the reservoir depth approach the practicable

suction head of the pumps. For continuity of operation during repairs and cleaning, this reservoir should be constructed in two sections with pump suctions connecting to each.

In conclusion, let us sum up the factors which point so strikingly to adequate storage as a most practical and economical solution of the fire reserve problem. A certain quantity of water is needed for a moderate number of hours to protect the lives and the property of the citizens of any city from destruction by fire. This necessary fire flow is much greater than the maximum rate of domestic consumption and becomes many times the domestic rate in the smaller municipalities. Where a sufficient supply of potable water is not readily available for maintaining this desired rate of fire flow, the cost of drilling sufficient additional wells or of constructing reserve filter capacity to equal from 5 to 35 times, the domestic rate would generally be a financial impossibility. It is the aim of every city to provide the maximum possible protection as a safeguard against disaster by fire. The water supply works should be developed to their maximum economical limit. The difference between the normal rate of yield of these works and the rate of flow necessary for efficient fire fighting, can usually be most economically provided by adequate storage. Such storage should be entirely elevated when practicable and mains should be of sufficient size and number to deliver the desired quantities to the various localities requiring protection. Where natural elevations are not available for reservoirs, a tank of substantial capacity on a tower of sufficient height will be a most valuable asset to economical operation and a real safeguard against interruption of service. The remaining portion of the desired rate of fire flow can then be most economically provided by reserve pumps drawing from a sufficiently large suction storage reservoir. It is in providing this storage that designing engineers and water superintendents have one of the greatest opportunities to increase the adequacy and the reliability of the water works of the smaller American cities.

DISCUSSION

C. M. Baker.[3] It is understood from Mr. Parson's paper that the Fire Underwriters require that a fire flow should be available for five hours for cities under 2500 population and for ten hours for

[3] Chief Engineer, State Department of Health, Madison, Wis.

cities over 2500 population to the next classification. In other words a city of 2600 would have to provide facilities for a ten hour fire flow while a city of 2400 population would be required to provide only for five hours flow. This sharp change seems inconsistent because it certainly is not reasonable to assume that there is actually this difference in the type of construction so sharply defined. It would seem, therefore, that a more gradual scaling should be provided.

The question of standby is extremely important. It is understood that the Fire Underwriters consider electric power from two sources satisfactory. It should be pointed out, however, that a few years ago a severe sleet storm in the central part of Wisconsin put practically every power line out of service. The city of Oshkosh, for instance, depending upon electric power only for pumping its raw water into the filters, found it necessary to bypass the filters at this time because of lack of auxiliary power. It would seem, therefore, that gasoline or other similar type of standby power would be of more real value than several sources of electric power.

A WEATHER BUREAU AT THE PUMPING STATION[1]

By Scotland G. Highland[2]

A weather bureau at the pumping station will bring the water-department on a scientific mission into every home in the city it serves. The people of the county in which the meteorological station is located will be enormously benefited because of the additional useful data collected and daily disseminated by the local newspapers.

VALUE OF WEATHER RECORDS

Business enterprises, like people, live, move, and have their being in the weather, to a far greater extent than is commonly supposed. There are in fact few callings or activities that can not be conducted with more efficiency and with greater economy by a more frequent use of weather records.

All civilized nations are giving special attention to meteorology. The existence of thousands of voluntary observers, and the profound interest in the weather actually taken by every individual, demonstrate that there is a demand for facts beyond our present ability to supply them.

The great difficulties inherent in modern meteorology should stimulate the devotion of the highest talent to the promotion of this branch of science. The practical value of the data collected justifies the expenditure of money and labor, in order that theories may be confronted with facts.

FASCINATING FIELD OF STUDY

The study of climatology in the United States is now regarded as a most interesting and valuable public service, affecting as it does the well-being of all life. Changes in climate are responsible for changes in the physical and mental activities of people. The comfort, and even the lives of the people, are intimately tied up with the weather.

[1] Presented before the New York Convention, May 23, 1924.

[2] General Manager, Clarksburg Water Board, Clarksburg, W. Va.

Aside from the immense value of a long series of meteorological observations, a wide and fascinating field of study is opened. It is the water supply, not the extent of territory, that limits populations, because the supply marks the limit of food production. Water sets the limit of progress of all life. Some day its supply may become the great anxiety of the urban population. The science of meteorology is unquestionably a subject that deeply concerns us all.

UNITED STATES LEADS WORLD

Under the direction of Professor Charles F. Marvin, the United States Weather Bureau is today the most efficient agency of its kind in the world. This country leads all other nations in the utility, practicability and extent of this public service. The shippers of perishable food and other products are told of the hot and cold waves their shipments will encounter en route to any destination. In the flooded areas of the great waterways, advices are given several hours in advance of the crest stages, often days, and sometimes weeks, generally to the fraction of a foot, which the flood will attain. The work of the Bureau has been limited only by the paucity of the funds available.

When we pause to consider the value of the service broadcasted daily by the United States Weather Bureau, and when we reflect upon the fact that everybody may have for the asking all data collected during the fifty-four years of its active existence, it becomes apparent that there is a debt unpaid. Because of the particular value of the service to the business in which we are engaged, waterworks men above all others ought to be the first to prove their gratitude by practical coöperation with the Weather Bureau.

That man may last but never live
Who much receives but nothing gives.

WATER WORKS WEATHER BUREAU

Because of mutual advantages shared with each other, water-works officials will wish to establish a fully-equipped weather bureau at the pumping station, and also join the United States Weather Bureau corps of trained, scientific observers. That the data collected have a popular, as well as a private and national interest, is evidenced by the demand for information eagerly sought by the local newspapers, for daily publication. During periods of excessive rainfall and tem-

perature extremes, requests come to the Water Works Weather Bureau from persons in practically every walk of life for authoritative information. The inquiry, "What's the rainfall or temperature?" is almost as common as "What's the time?"

4500 meteorological observers

The United States Weather Bureau maintains at the present time 200 full reporting paid stations, telegraphing reports daily to the central offices in Washington. In addition to these, there are 50 stations of less importance furnishing telegraphic reports at certain seasons of the year. There are 1000 special observers who render reports in the interest of crops, as the Corn and Wheat Service, River and Flood Service, etc., usually during portions of the year. The coöperative force of the Weather Bureau is made up of 4500 observers, who each day record the temperature and rainfall.

Weather Bureau publications

Every water-works department ought immediately to obtain for its office files all the data collected and published by the Weather Bureau. These invaluable bulletins include the following: "Climatological Data for the United States by Sections; Climatological Data, State section; Monthly Weather Review; Crops and Market Bulletin; Weekly Weather and Crop Bulletin; and Snow and Ice Bulletin."

It will be possible for coöperative meteorological observers to obtain in their respective states the monthly Climatological Data Bulletins covering a past period of twenty-five years. This means that, if any interested person should want to know what the rainfall and the temperature were on December 25, in any county in the state, twenty-five years ago, or at any later date, these bulletins would disclose the facts.

The monthly publication entitled, "Climatological Data for the United States by Sections," is simply the bulletin of each state bound in a single volume. If anybody wishes to know what the rainfall and the temperature were in San Francisco, California, on December 25, 1923, or at any later date, in any part of the United States, the information is available in these volumes. These publications will form a nucleus around which a complete meteorological library may be built up for the enlightenment of the general public.

King Pharaoh's dream

The Old Testament narrative of King Pharaoh's dream and the prophetic interpretation by Joseph may well be remembered now. What Joseph did was to take advantage of seven moist years, when crops were bounteous, and put in storage great quantities of grain, as a provision against dry years that were to follow. He knew the value of storage in times of excess. The Weather Bureau has taught us that water must be stored in times of plenty against protracted scarcity, just the same as any other commodity.

Stream flow measurements

More river-gaging stations and much more intensive measurement of precipitation are needed. An important fact worth noting is the almost entire lack of uniformity of behavior of any two streams, which indicates that the discharge of a stream is a law unto itself and must receive individual study of the great accuracy, over a series of years. An automatic river-stage recorder installed at a point just above the dam, and a careful record kept of the height of the stream, will afford data of enormous, practical value. The United States Geological Survey will establish a rating curve and a rating table for any stream giving the daily rate of discharge in second-feet from zero to flood heights, at a cost of railroad fare and subsistence for the engineers who make the survey.

Temperature and rainfall stations

In order to obtain accurate rainfall data for each watershed, one or more rain-gages must be installed on each of the principal tributaries of the main stream from which a public water supply is drawn. Paucity of rainfall data hampers the engineer, compelling him to feel and guess his way in many important fields. The Clarksburg Water Board, Clarksburg, West Virginia, has installed and maintains twelve rainfall stations on its watershed, comprising an area of 385 square miles. A recording rain-gage for determining the intensity of rainfall is maintained at the pumping-station. Observers in charge of the rainfall stations on the watershed are requested to furnish the farmers and all other interested persons with the data collected. Maximum and minimum registering thermometers have been installed at five of the twelve precipitation stations for the sole benefit of the people residing on the watershed.

RECORD IN BRITISH ISLES

The number of rainfall stations in the British Isles has increased from 471 in 1861, to 5543 in 1924, or one precipitation station for each twenty-two square miles of land area.

Evaporation data

Evaporation data have value beyond the confines of the state in which they are collected. A knowledge of the rate of evaporation of surface waters is essential to the efficient management of a water-plant. Therefore, an evaporation station, including an anemometer and a hook gage, for testing the daily rate of evaporation, is a necessary apparatus.

Frost penetration in streets

Accurate measurements of frost penetration in city streets is readily seen to be of vital importance to a water-department in determining the depth to which water-mains and service-lines should be buried, in order to avoid the damaging action of frost. Soil thermometers for ascertaining the temperature of the soil at various depths, from one to eight feet, of the pattern devised by the New York Agricultural Experiment Station, can be installed close to the plant and at a location representative of street conditions. A separate thermometer is required for each foot of depth investigated.

Wind velocities

Accurate records of the velocity and direction of the wind are essential elements in all meteorological and climatological work, as well as of value to business interests. A recording anemometer for ascertaining the velocity of the wind is an important instrument. Instructions for installing the instruments are furnished by the United States Weather Bureau and by the water-resources branch of the United States Geological Survey, Washington. All data collected are reported to these government agencies. The reports are promptly published in the official monthly bulletins, which are quickly distributed among interested persons all over the United States. The published data are available to the people all over the world.

List of approved instruments

The equipment consists of the following instruments of Standard Weather Bureau pattern:

1. An automatic river stage register
2. A set of maximum and minimum registering thermometers
3. A recording rain-gage
4. A recording anemometer
5. A mercurial barometer
6. A whirling psychrometer
7. Soil thermometers
8. An evaporation station
9. One or more standard rain-gages on each of the principal tributaries of the watershed

Intensive study of weather phenomena

Intensive studies of local weather phenomena, made by trained water-department observers, will aid forecasters. Widely varying temperature forecasts are sometimes required in the fruit districts for two almost contiguous sections. The data collected and preserved will have a future value beyond any estimate which we may place upon it today.

Truths of nature

It is said that a bee, if laden with honey, is allowed to enter any hive with impunity. The meteorological observer, laden with the truths of nature, is welcome everywhere.

The speaker had the honor to present a paper on this subject before the Detroit Convention of the American Water Works Association on May 22, 1923, entitled, "Collection and Daily Publication of Meteorological Data by the Water-Department," the full text of which is printed in the JOURNAL, volume 10, no. 6, 1923.

The purpose of the present paper is to bring to the discussion of this subject such additional information as is now available as a result of another year's experience.

OVER-CHLORINATION FOR TASTE CONTROL[1]

By W. B. Bushnell[2]

The purpose of this paper is not to discuss the theory of over-chlorination but to furnish a history of a single experience of the Champaign and Urbana Water Company in the hope that it will develop discussions which will prove of benefit to the society.

We have a covered clear water reservoir which, at periods of the year, is a breeding place for gnats that lay eggs that hatch into red worms which in turn develop into gnats, which gnats lay more eggs, etc. While these worms are not harmful to the health they are a decidedly disagreeable adulteration of an otherwise pleasant water and our consumers have a way of objecting to them when they appear in their drinking glass. We have been much concerned by this difficulty, have put into effect several plans suggested by different authorities and tried out ideas of our own hoping to end the invasion of these red worms.

Our last effort was made last September. A short time previously we had taken out glass windows in the reservoir roof and made it light tight and thought if the worms and gnats were once entirely removed they would not reappear. On September 4, 1923, we admitted 20 pounds of free chlorine into our 750,000-gallon reservoir. We hoped that this would kill the gnats. Our efforts were successful. We killed the gnats and from the taste that appeared the following morning in the water we were under the impression that we had killed almost everything else in the universe and that it had in some mysterious manner found entrance into our mains. This taste continued, being at its worst between September 8 and 14. We were of the opinion that there had been some crenothrix in our mains and that the extra dosage of chlorine had killed this, thus producing the taste and that it would be only a question of a short time before this would disappear. However, it had not materially disappeared on

[1] Presented before the Illinois Section meeting, March 20, 1924.

[2] Supervising Engineer, Champaign and Urbana Water Co., Champaign, Ill.

September 18, at which time we increased our regular dosage of chlorine into the influent of our filters from 15 to 20 pounds per day. The following morning the taste in the water was noticeably diminished and in a short time entirely eliminated. At this time our chlorinator was equipped with an orifice tube of 20 pounds per day maximum capacity. On October 1, 1923, a new orifice tube was installed of maximum capacity of 80 pounds per day. For a few days following this we fed chlorine into the wash water at the rate of 50 pounds per day for the purpose of sterilizing our filter beds. We still continue the dosage into our filter influent at the rate of 20 pounds per day and have had no recurrence of the taste. We have had no more gnats in the reservoir, but the real test in this regard will come in the spring as they do not appear during the winter months.

DEVELOPMENT OF THE CHARLOTTE WATER WORKS[1]

By W. E. Vest[2]

The first recorded history of a movement to obtain a public water supply for the City of Charlotte, that the writer has been able to find, dates back to the year 1870 when the City Council went on record as realizing the necessity for a complete water plant which would deliver an ample supply of water for domestic use, fire protection, and for manufacturing purposes.

The method used at that date, more than fifty years ago, of getting into action for carrying out the conclusions that a water works plant was needed, was much the same as we practice in this generation. The City Council appointed a Committee whose duty should be to procure the services of a competent engineer to make necessary surveys, formulate plans in detail with an estimate of cost, and to have the facts presented to a full meeting of Council, together with the recommendations of the Committee. The Committee did its work, as instructed, and made its report within a few months after its appointment, but, for some reason or other, the proposed work did not progress beyond the stage of filing the report and paying the engineer for his services.

There is some evidence in hand that Charlotte had at that time some tanks (probably underground cisterns) in the vicinity of the most hazardous fire risks, in which water was stored for fire quenching purposes. An effort was made during the latter part of the same year to bring water from a near by lake, or pond, to the center of the City where it would be stored in a central tank, and by means of a system of pipes could be distributed to other tanks, or underground cisterns, that had already been built. These underground cisterns were built in the streets, and the water stored in them was suitable for fire fighting purposes only. They were built of brick and mortar with arched covers. Man-hole ring-and-cover openings were placed in the top, through which suction hose could be used in drawing water by the steam fire engines of the fire department.

[1] Presented before the North Carolina Section meeting, November 12, 1924.
[2] Superintendent, Water Department, Charlotte, N. C.

In 1871 the City Council went so far as to pass a resolution calling for a vote of the people to authorize an expenditure of $50,000 for a system of water works, but nothing further was done toward the actual carrying out of the proposed enterprise. During the time that elapsed between the years 1871 and 1880 several ordinances were passed by the different Boards of Aldermen looking to a water plant, but none of them seems to have lived longer than the necessary time for the city councilmen to change their minds and rescind the action that had been taken at previous meetings.

In the light of what transpired in 1880, there is room for some speculation as to what was in the mind of the various governing bodies of the city relative to the advisability of establishing a municipal water works plant; for on October 18, 1880, a Committee was appointed by the Board of Alderman to make investigation of a proposal from people outside of the City, looking to the establishing of a privately owned plant under contract with the city, in which the necessary guarantee for the protection of all interested parties would be set up and recorded. This Committee evidently went about its work with much earnestness, for, on February 7, 1881, it made a favorable report on a form of contract to be entered into and the same was adapted on the same day. The contract was dated March 17, 1881, and was to have been operative over a period of thirty years. The city subscribed for forty-five public fire hydrants and obligated itself to pay $2000 per year for the necessary ever-ready service that the fire hydrants would provide. The contractor was required to erect a plant capable of furnishing 100 gallons per day for each in habitant, and the necessary water for fire fighting and other public use in addition. The name of the water company was officially made, Charlotte City Water Works Company, and the plant was put into operation in 1882 or 1883.

The source of supply was Little Sugar Creek and the intake was about one mile from the center of the city. Filtration of water, even from surface supplies, was not considered as great an essential in that day as it is at this time, and many have been the occasions when Charlotte citizens could not distinguish much difference between a glass of water and a glass of cider, by the appearance of the two. Impounding reservoirs were used for the two-fold purpose of ample supply and for purification.

Differences between the citizens, registered through the governing body of the City, and the water company, date back as far as 1890,

and from that time on through the years to 1899, the water company went through a rather stormy period.

In the summer and fall of 1896 an additional supply of water was brought into use from Briar Creek where an auxiliary pumping station was established at a point about three miles from the centre of the city. A complete filtration system was also established at that time.

Charlotte voted favorably on a $300,000 bond issue in February, 1896, for the purpose of establishing water works and sewer systems. Surveys, plans, estimates and recommendations were made, but the establishing of a municipal plant was delayed because of the fact that the water company had made extensive improvements, thereby placing itself in position to render good service, and for the further reason that wise judgment prevailed to prevent building a new plant as a competitor of the water company.

During the year of 1898 negotiations were completed for the sale of the privately owned plant to the city, and the complete transfer was made by deed, the municipality taking full charge of its water works January 1, 1899.

Soon after the city became the owner, it appeared that the Sugar Creek source of supply would have to be abandoned, or the city would stand in the way of the establishment of desirable industries that wanted to locate on the water shed above the intake. At that time the Briar Creek supply was regarded as sufficient for only a few years, and that to establish additional pumping equipment and pipe line capacity to bring in the full stream would entail an outlay of money that was not justifiable for the short period that the supply would be sufficient for the city's needs.

The government of the new department was exercised by the Board of Aldermen until March 8, 1899, when the newly appointed Board of Water Commissioners, set up by legislative enactment, took full charge of the property as administrative manager. Under the rules and regulations established by the Board of Water Commissioners at its first meeting on April 28, 1899, the newly acquired water works plant was named Charlotte Water Works, and the universal meter system for all water users, except for fire protection, was put into force.

During the four years, 1899 to 1903 inclusive, proposals and suggestions looking to building a new filtration plant, storage reservoir, and pumping station with ample equipment were before the people

all the time. This project was finally authorized and a storage pond made on Big Sugar Creek (now called Irwin Creek) at a point about two miles from the center of the city. A filtration plant having a rated capacity of 5,000,000 gallons per day of twenty-four hours was constructed and has rendered efficient service from the date of its starting in 1905 until the end of July of this year when it was abandoned entirely because of its bad location in relation to the present source of supply, rather than to repair old equipment, and increase the capacity on the same plot of ground.

It was provided with electrically driven centrifugal pumps for the main work and with steam driven pumps for emergency use.

The favorite coagulant used from the date filtration was first started in 1896, to the present time, has been sulphate of alumina. Sulphate of iron has been tried, but not continued because it was not well suited to our water. As an extra precaution that no polluted water should be pumped into the mains of the city, chloride of lime was used from about 1907 to February, 1916, as an additional agent for purification.

Since the last named dated liquid chlorine has replaced chloride of lime.

The next never-to-be-forgotten epoch in the history of the Charlotte Water Works was the memorable water famine during a portion of the summer of 1911. The creek supplying the storage pond went practically dry; so dry that minnows could not move from swimming hole to swimming hole. It was no trouble that summer to get our citizens to provide quickly the necessary funds for building a pumping station on Catawba River and laying a large pipe line 10¼ miles long from that point to the city. The necessary surveys, estimates, and the letting of contracts, were done within a few months. Construction went forward as fast as the contractor would proceed of his own volition and under the urgent requests for speed that were made by the Board of Water Commissioners, the Consulting Engineer, and the Superintendent of the Water Department. Catawba Station, our present place of supply, was put into operation in April, 1912. Since that time Charlotte's water problems have been much less aggravating than they were in former years.

A single line of 24 inch cast iron pipe reaches from this station to the city. The first 5¾ miles of the line is used as a force main to deliver raw water into a storage reservoir of 60,000,000 gallons capacity. The remainder of the line is likewise a single 24 inch cast iron main that delivers water by gravity to the filtration plant.

The filtration plant put in operation in 1905 was equipped with wooden tubs which showed unmistakable signs of decay as early as 1918, but by partial rebuilding, patching, and reinforcing, they were made to do efficient work until a new, larger and more modern plant could be provided.

In 1922, active steps were taken to provide a new filtration plant and pumping station. This development has progressed to the point of putting the entire new works into operation, and over a period of more than three months of full operation, the results have been very satisfactory.

The main structures of this new station consists of chemical house with well equipped laboratory, coagulation basins, filters having a rated capacity of 8,000,000 gallons per day, pumping room, clear water storage basin holding 3,000,000 gallons, surge tank, wash water tank, and elevated tank of 1,000,000 gallons capacity at the head of the distribution system. Modern devices for full control, and for economical and easy operation, have been installed throughout the works.

The subject announced in this paper is much longer and wider than has been touched on in the foregoing, and to do partial justice to its name something should be said on the subject of the distribution system. The ways and means of producing something are of prime importance, though of no less importance are the ways to get the product to the place of delivery. In planning the distribution system, or in making extensions to the same, it has been more difficult to say if a big pipe should go here, there, or elsewhere, than it has been to say a certain source is the proper place from which to get our water and to say how much we should provide to bring in.

For many years Charlotte has grown more rapidly toward the south and east than in the opposite direction, and all the while the water works plant has been in the northwestern part of the city.

When the location for the new filtration plant came up in 1922, the main factors that influenced the decision were, closeness to the line that brings raw water from Catawba River, nearness to the center of the distribution system, availability of land at a reasonable price and at such elevation as to allow taking full advantage of all the head attained in the force main as the water passes over the divide between Catawba Station and the city, and the accessibility of the site as to roads, streets and railroad.

Some portions of our distribution system seem to have been very

wisely planned, while other portions appear not to have been done so well. These faulty conditions have been brought about largely by failure to have been able to guess where industries would locate, where hazardous fire districts would grow up, and the trend that increasing population would take. Another influence has been a lack of funds always to follow plans that the best judgment dictated.

The fact that the Charlotte Water Department has been able to earn and collect a little more money than was necessary for interest on indebtedness, for maintenance, for depreciation, and for operating expenses, and has been allowed to use the surplus in betterments and extensions, has been a material help in its development. During the past fifteen years, it has not been necessary to ask for any money from the general tax fund, nor has it been necessary to borrow money every time a small, or modest length, extension was needed.

At this time the plant is serving efficiently an estimated population of between 60,000 and 65,000 and has capacity in its raw water line, filtration plant, and pumping station equipment to supply an additional population of 20,000 to 30,000 people.

The cost of the water works system to date stands at $2,245,900, of which $1,667,000 is bonded indebtedness and $578,900 is surplus earnings that have accrued during the past twenty-five years and have been expended in betterments and extensions.

HYDROGEN ION CONCENTRATION AND PEPTONES USED IN BACTERIOLOGY[1]

By E. M. Chamot[2] and F. R. Georgia[3]

INTRODUCTION

The evolution of methods used by American water analysts is fairly well reflected in the various editions of Standard Methods of Water Analysis, A. P. H. A. (1). This is especially true as regards the methods employed in the adjustment of the reaction of culture media, starting with titrations using phenolphthalein as indicator and then introducing methods involving adjustment to definite hydrogen ion concentrations with the final elimination of the phenolphthalein methods.

All recent workers seem to be agreed on the lack of correlation between the older methods for the adjustment of reactions by titration with phenolphthalein as indicator and the newer hydrogen-ion concentration adjustments. The voluminous literature is very well covered by the bibliography in Clark's "The Determination of Hydrogen Ion," second edition, (2). A recent paper by Bunker and Schuber (3) is, however, of special interest to water analysts. They offer some criticism of methods and make certain specific recommendations regarding the adjustment of specific media.

For many years most bacteriologists used "Witte" peptone in the preparation of media, but war conditions brought about the introduction and widespread use of many other brands. This condition is also reflected in the later editions of the Standard Methods.

Early work by Gage and Adams (4) and by Sedgwick and Prescott (5) had shown that different results were to be expected when dif-

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ferent peptones were used in culture media. More recently Wright (6) Tilley (7), and Wilcox (8) have recorded variations due to employing different peptones in media used in testing disinfectants, for indol production, and for toxin production.

The writers in common with others experienced difficulty in obtaining satisfactory results when "Witte" peptone was displaced by others. With the first peptones used, considerably higher acidities, as measured by the titration method, were noted as compared to those obtained with "Witte" peptone. Different domestic peptones gave different results in this respect. Experience had shown that when "Witte" peptone was used the old titration method for the adjustment of reaction gave satisfactory results and results that could be duplicated, but it was soon noted that when the same methods were applied to media made with other peptones unsatisfactory results were obtained.

It appeared that at least two variables needed study, i.e., the different peptones and the reaction. The peptones studied were labeled as follows: Parke, Davis, & Co., Bacteriologic Peptone; Frederick Stearns & Co., Peptonum Siccum Stearns; Fairchild Brothers and Foster, Pepton Fairchild; Armour and Co., Peptonum Siccum; Digestive Ferments Co., Bacto Peptone and Proteose Peptone; E. R. Squibb and Sons, Meat Peptone Squibb, Dry; and some "Witte" peptone obtained from C. A. F. Kahlbaum before the war. All of these, with the exception of the "Witte" peptone, which was used for comparison, were presumably of American origin. It is not known whether the label is that of the manufacturer in all cases, since information that we have would indicate that some peptones are sold under more than one label. Reactions were measured in terms of hydrogen ion concentration.

APPARATUS

The apparatus used for the measurement of hydrogen ion concentrations consisted of a Leeds and Northrup Type K potentiometer and Type R galvanometer, a Weston cadmium cell, normal calomel electrodes, and Bunker type hydrogen electrodes. Electrolytic hydrogen, compressed in cylinders, was used after traces of oxygen had been removed by passage over a long spiral of chromel wire heated to dull redness by means of an electric current. Twentieth molecular primary potassium phthalate was used frequently as a check on the accuracy of the electrodes.

The apparatus was capable of giving results of much greater accuracy than that necessary for bacteriological work, and with this fact in mind the pH

values were recorded only to two decimal places and no corrections were made for temperature, or other minor factors. The pH values were taken directly from the tables of Schmidt and Hoagland (9).

EXPERIMENTAL

Part I

The first part of the work was devoted to a study of the effect of the addition of acid and alkali on the pH value of the solutions of the eight different peptones. For this purpose solutions having a

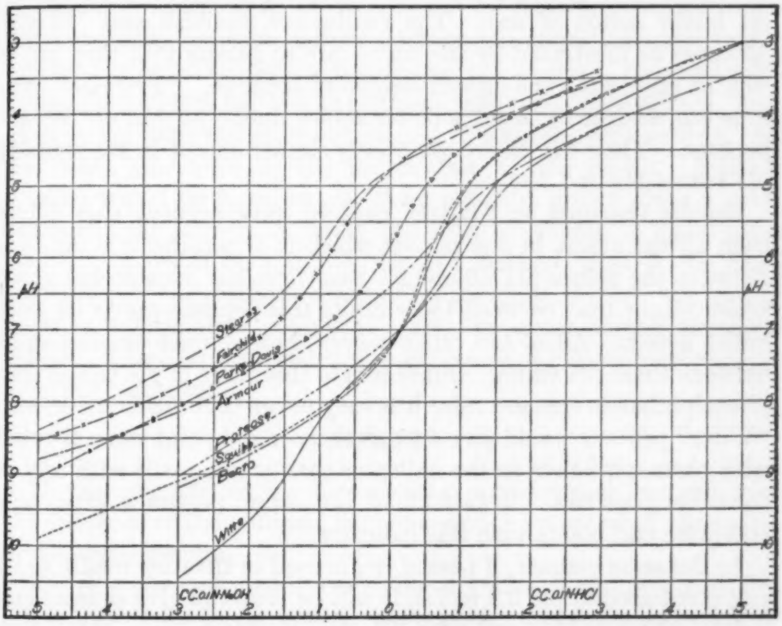

Fig. 1. Titration of 10 cc. Portions of Peptone Solutions, Containing 3 Grams of Peptone per 100 cc., with 0.1 N HCl and N NaOH

strength of 3 grams of peptone in 100 cc. were used. Ten cubic centimeter portions of these solutions were measured into suitable tubes and various amounts of 0.1 N HCl and of 0.1 N NaOH added to them after which the pH values were determined. A duplicate set of determinations was run on each peptone. Curves for the various peptones were plotted from these data, a typical set being shown in figure 1.

By reference to these curves it is seen that the peptones may be

roughly divided into three groups. In the first, we have "Witte," Squibb's, "Bacto," and "Proteose" which are slightly alkaline when unadjusted. In the second, we have Armour's and Parke-Davis' which are acid. The third group includes Fairchild's and Stearns' which are highly acid. For the purposes of this investigation the value pH = 7.0 is considered to represent true neutrality.

The curves as obtained for Stearns' and Fairchild's peptones are quite similar and show close agreement throughout their entire lengths. That for Parke-Davis' is somewhat similar but is located in a different range of pH values. Armour's peptone shows the greatest buffer action of any. The results for Squibb's and "Bacto" peptones as illustrated by the curves are so similar that they might well be duplicate runs on one sample of peptone. "Proteose" peptone was designed to exert a buffer action similar to that of "Witte" peptone. Their curves are essentially similar except in the range of pH values above 7.5

Results obtained on "Witte" peptone gave a curve that differs from all the others in one respect which is of considerable interest. Between the values pH 8.0 and 9.0 this curve has its steepest slope, which means that between these limits this peptone exerts its least buffer action. All of the other curves show a much smaller slope between these pH values. Since it is in this range of pH values that phenolphthalein changes color it is easy to see that media made with "Witte" peptone would give a much sharper end point when titrated with phenolphthalein as the indicator than media made with any of the other peptones. In fact all of the other peptones give very indefinite end points with this indicator.

In the same manner, if phenol red is used in titrating media to an end point around pH 6.8 to 7.0, it will be found to give sharper end points with Squibb's and with "Bacto" peptones, since the curves obtained for these peptones are steeper in this range than for any of the others.

With the exception of the similarities pointed out above the peptones differ considerably in their buffer actions and initial acidities. They therefore require different amounts of alkali or of acid to change their reactions from one pH value to another, or from their original reactions to some definite pH value. For the same reasons attempts to adjust reactions by reference to some datum point, such as the end point obtained by titration using phenolphthalein as indicator, will result in totally different pH values in the adjusted media.

In the titrations of these solutions, using phenolphthalein as indicator, end points were obtained which corresponded with pH values anywhere from 8.5 to 9.0. This variation was largely due to the marked buffer action of the solutions between these two limits and partly to the interfering colors of the peptones in some cases.

In a similar manner titrations with phenol red as indicator gave results corresponding to pH values between 6.8 and 7.2.

It would appear from the foregoing that, if media are to be adjusted to any definite pH value, one of several procedures will be necessary. If phenolphthalein is to be used it will be necessary to determine experimentally for each culture medium the amount of adjustment required in order to obtain the desired pH values. The successful application of this method presupposes the use of ingredients, such as peptone, from the same source and of constant composition, and the same procedure in the preparation of the media. Another method would be to make use of an indicator which gives a color change at the proper pH value and then to titrate to that point directly. Lack of definition as regards the end point is the chief objection to this method. Still other methods involve the use of various colorimetric comparison sets or electrometric measurements. These later procedures in the hands of experienced workers give the best results.

Part II

The second part of the investigation was devoted to a study of the influence of the different peptones and the reaction of the media on bacterial growth.

For this purpose media containing 3 grams of the peptones and 0.5 grams of KCl per 100 cc. were used. This concentration of peptone had been found best by Chamot (10) and his co-workers in previous investigations. Chamot (11) had also shown that KCl was superior to other salts for the stimulation of growth.

It was found by trial that KCl had no appreciable effect on the buffer actions of peptones. In support of this, curves for "Witte" peptone with and without KCl are shown in figure 2.

Since water analysts are always concerned with the detection of members of the colon group of organisms in the examination of potable water it was decided to use Bacillus coli in the experiments which follow.

FIG. 2. CURVE I: TITRATION OF 10 CC. OF SOLUTION CONTAINING 3 GRAMS OF "WITTE" PEPTONE PER 100 CC. CURVE II: TITRATION OF 10 CC. OF SOLUTION CONTAINING 3 GRAMS OF "WITTE" PEPTONE AND 0.5 GRAMS OF KCl PER 100 CC.

The organism, which was isolated from a polluted surface water, was a motile, gram negative rod, and showed no spores. It fermented lactose with the production of gas, was capable of growing aerobically, produced typical colonies on Endo's medium, gave typical gas production and color reaction in neutral red medium, and was methyl red positive after four days incubation in Clark's medium prepared from "Proteose" peptone. It was, therefore, a typical culture of B. coli according to the requirements of the Standard Methods of Water Analysis, 1920, of the American Public Health Association.

This culture was carried along from day to day in an unadjusted medium containing 3 grams of "Proteose" peptone and 0.5 gram of KCl per 100 cc. "Proteose" peptone was chosen for this purpose because it had been placed on the market as a substitute for "Witte" peptone in certain media, and it was hoped that it would give similar results.

Since the water analyst frequently has to deal with bacteria that have been living under conditions unfavorable for their growth, a method was adopted for the determination of optimum hydrogen ion concentrations for the growth of B. coli, in media prepared from the various peptones, which involved an exposure to artificially produced unfavorable conditions and which admitted of definite control. The method used was in many respects similar to the procedure used in the determination of phenol coefficients on disinfectants. References to these methods are given by Tilley (12).

The procedure used in this investigation is given below.

For the purpose of making a determination of the optimum pH value for the growth of B. coli in a given peptone, a solution was prepared containing three grams of the peptone and 0.5 gram of KCl per 100 cc. This solution was divided into eight portions and each portion was then adjusted to a different pH value by the addition of suitable amounts of normal KOH or HCl, filtered if necessary, tubed and sterilized in the autoclave at 15 pounds for fifteen minutes after the pressure had reached 15 pounds. The amount of medium placed in each tube was 10 cc. The pH value of each portion was determined after sterilization so as to give the reaction of the media as actually used.

Short test tubes having a diameter of 25 mm. were used as seeding tubes. Eight of these sterile tubes were taken, one to correspond to each of the above mentioned portions of culture medium, and into each was measured 0.1 cc. of a twenty-four-hour culture of the B. coli previously described. Five cubic centimeters of a phenol solution of a strength suitable for the purpose at hand were then added to each of the seeding tubes at one-half minute intervals and thoroughly mixed by shaking. At the end of five minutes a transfer was made from the first seeding tube to a tube containing 10 cc. of one of the eight portions of the medium. A half-minute later a transfer was made from the second seeding tube to a tube containing one of the other portions of the medium, and so on until transfers from all had been made. This procedure was repeated every five minutes up to and including the thirty-five minute period. No attempt

was made to control the temperature except to have all tubes at room temperature. The loops used for making the transfers were of a form similar to that described in the report of the committee on Standard Methods of Examining Disinfectants (13).

The tubes were incubated at 37.5°C. and then examined for growth. Several determinations were made for each peptone. A typical set of results is given in table 1.

TABLE 1

Determination of optimum pH

"Witte" peptone. Phenol 1:100

NUMBER	MINUTES EXPOSURE							pH
	5	10	15	20	25	30	35	
1	+	−	−	−	−	−	−	7.80
2	+	+	+	−	−	−	−	7.42
3	+	+	+	+	−	−	−	6.99
4	+	+	+	+	+	−	−	6.57
5	+	+	+	+	−	−	−	6.11
6	+	+	+	−	−	−	−	5.83
7	+	+	+	−	−	−	−	5.66
8	+	+	−	−	−	−	−	5.40

TABLE 2

Optimum reactions for the growth of B. coli in media containing 3 grams of peptone and 0.5 grams of KCl per 100 cc.

PEPTONE	OPTIMUM pH
Parke-Davis	5.7
Stearns	5.7
Fairchild	5.8
Armour	6.3
"Witte"	6.6
"Proteose"	6.9
"Bacto"	7.0
Squibb	7.0

There can hardly be any question but that the exposure of the culture to phenol as carried out in these tests resulted in a gradual inhibition of the organism. It is thus fair to assume that that medium in which growth is obtained after longest exposure to the phenol is most suitable for the growth of the organism. Since the various media prepared from the same peptone differed only in their reactions, the pH value of that medium giving growth after the long-

est period of exposure of the culture to phenol may be taken as at or near the optimum. These optima are shown in table 2 and are indicated by arrows on the hydrogen ion titration curves for the various peptone KCl media shown in figure 3.

Although the optimum pH values for the peptones are given as definite figures in table 2 it must be remembered that satisfactory growth is obtained over a range, amounting in some cases to one whole unit on the pH scale. A variation of from 0.2 to 0.3 pH on either

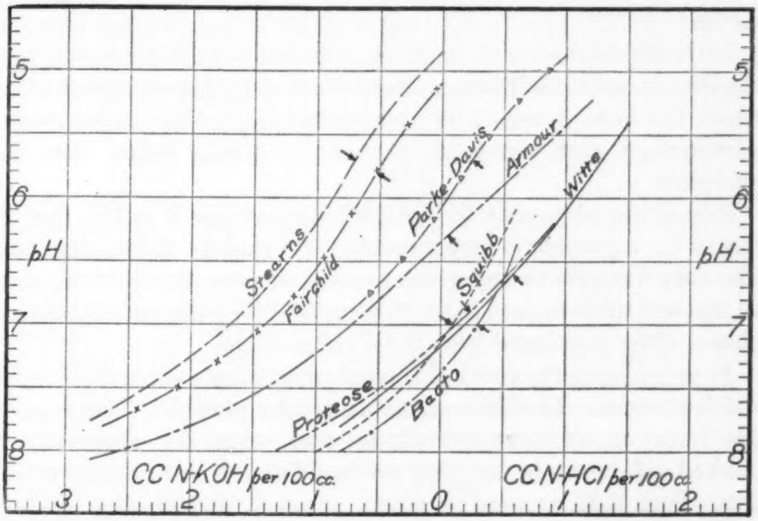

FIG. 3. HYDROGEN ION CURVES PLOTTED ON THE ADJUSTED MEDIA, USED IN THE DETERMINATION OF OPTIMUM pH POINTS FOR THE GROWTH OF B. COLI, AFTER STERILIZATION

Arrows indicate optimum pH values for B. coli

side of the values given may, therefore, be considered premissible for B. coli in the simple media used in these experiments.

The optimum pH values appear to bear no relation to the degree of the buffer action of the peptone. If the curves in figure 3 are examined it is found that these values do not correspond with the points of greatest or of least buffer action, but are located at intermediate positions. Inflection points on the curves exhibit the same lack of relation. About the only general statement that can be made is that those peptones that give solutions more highly acid than

indicated by pH = 5.7 require adjustment to that value while those that give less acid solutions require but little adjustment.

The essential fact derived from these experiments is that, for the cultivation of B. coli, quite different optimum reactions were obtained for media made from different peptones, but which were similar in other respects. Statements which appear in the literature with regard to optimum reactions for the cultivation of bacteria are, therefore, of little value unless accompanied by complete information regarding the ingredients used in the preparation of the culture media.

In the determination of the above optima it was our desire that they should represent conditions most suitable for the growth of organisms which had been living under unfavorable conditions, since in water bacteriology such forms are probably the rule rather than the exception.

Phenol was chosen as the inhibiting agent and it is felt that its rôle in the experiments here presented was entirely of this character. The only variable in any given experiment was the reaction, since all transfer tubes in each individual test received the same amount of phenol when inoculated from the seeding tubes.

In order further to check this point experiments were performed in which mercuric chloride was substituted for phenol. This reagent was found much more difficult to work with, due apparently to marked differences in the effect produced on the culture from day to day. Such data as were obtained, however, indicate that entirely similar results are to be expected. Mercuric chloride was selected because its action on bacteria is of a different character from that of phenol.

In order to get a comparison of different peptones under the same conditions, as regards their abilities to grow B. coli, media were made from each and adjusted to the optimum reactions previously determined. A series of tests were then performed using the same technique employed in the determination of optimum pH values except that tubes containing the media prepared from the eight peptones were substituted for the eight portions of medium from one peptone.

The results showed that on the whole "Witte" peptone is slightly superior to the others. It is closely followed by "Bacto," Parke-Davis', and Armour's. Fairchild's gave the poorest results and is

closely followed by Stearns'. "Proteose" seems to fall between these groups. Squibb's peptone was obtained too late to receive as thorough a comparison as the others. It resembles "Bacto" peptone in most respects but does not appear to give as good growth.

Part III. Indol production

The water bacteriologist frequently has occasion to make tests for indol production in cultures as an aid in the diagnosis of species. For this purpose simple media of the type used in this investigation are ordinarily employed. It was, therefore, thought advisable to make comparisons of the indol production by B. coli in media prepared from the eight peptones.

TABLE 3

Rate of indol production

PEPTONE	1 DAY	2 DAYS	3 DAYS	4 DAYS	5 DAYS
Parke-Davis'	Very weak	increasing to		moderate	
Stearns'	Weak	increasing to		moderate	
Fairchild	None	increasing to		very weak	
Armour	Very strong	increasing to	very	very strong	
"Witte"	Very strong	decreasing	slightly to	strong	
"Proteose"	Very strong	decreasing	slightly to	strong	
"Bacto"	Very weak	increasing to		weak	
Squibb	Weak	increasing to		weak	

Tilley (7) in 1921 reported the results of an investigation of this sort. He found considerable variation but inasmuch as he designated his peptones by number, and not by name, his findings are only of value in so far as they serve as a warning against the indiscriminate use of any peptone for tests of this kind.

In order to obtain more definite information, tubes of the media employed in comparing the different peptones were inoculated daily up to and including five days with a culture of the B. coli previously used. On the sixth day comparisons of the intensity of the reaction for indol were made both as regards variations in the same peptone with time, as well as between the different peptones for each of the five day intervals. The results of these comparisons are recorded in tables 3 and 4.

TABLE 4

Comparisons of peptones with regard to indol production

1 DAY	2 DAYS	3 DAYS	4 DAYS	5 DAYS
Armour	Armour	Armour	Armour	Armour
"Proteose"	"Witte"	"Witte"	"Witte"	"Witte"
"Witte"	"Proteose"	"Proteose"	"Proteose"	"Proteose"
Stearns	Stearns	Stearns	Stearns	Parke-Davis
Squibb	Parke-Davis	Parke-Davis	Parke-Davis	Stearns
Parke-Davis	"Bacto"	"Bacto"	Squibb	Squibb
"Bacto"	Squibb	Squibb	"Bacto"	"Bacto"
Fairchild	Fairchild	Fairchild	Fairchild	Fairchild

The peptones are arranged in the order of the intensity of the reaction for indol for each day. The brackets are used to indicate similarities in the intensity of the reaction.

Only three of the peptones studied were found to be suitable for use in connection with indol tests. Armour's peptone was found to be best in this respect but was closely followed by "Witte" and by "Proteose" peptones.

Indol production by bacteria in a culture medium is dependent on the presence in the medium of tryptophan or of compounds containing tryptophan. The peptones were, therefore, tested for tryptophan using both the vanillin and p-dimethylaminobenzaldehyde reagents. There was a lack of agreement between the results obtained with the two reagents, those with vanillin being much more nearly correlated with the indol results, but even in this case the intensity of the reaction for tryptophan could not be used as a criterion of the value of the peptone for indol tests. This lack of relation may be due to differences in the way the tryptophan is held in combination in the different peptones.

Although the vanillin test for indol may be more sensitive, p-dimethylaminobenzaldehyde was used since comparisons were more easily made.

The reagent was made by dissolving two grams of p-dimethylaminobenzaldehyde in 50 cc. of 95 per cent alcohol and then adding 50 cc. of concentrated HCl. In making a test the culture tube was inclined and 0.5 cc. of the reagent was allowed to flow down the side of the tube so as to form a surface layer. The color with indol develops almost immediately. The colors with tryptophan take much more time to appear so that, if comparisons are made within a few minutes after adding the reagent, there is no interference.

"Witte" peptone had been the standard of the bacteriologists for many years and had been shown by Chamot and Redfield (10) to be quite uniform in composition. In order to see if this uniformity is still maintained in "Witte" peptone and whether or not the other peptones are also uniform in composition, hydrogen ion titration curves were constructed for some "Witte" peptone obtained from Kahlbaum in 1921 and for samples of the other peptones obtained over a year after the first lots were purchased. In all cases the results obtained on the duplicate samples were in substantial agreement with those obtained on the originals.

SUMMARY

1. Curves are presented which show the variations in hydrogen ion concentrations of different peptone solutions with the addition of alkali or of acid.

2. Similarities in the buffer actions are pointed out.

3. "Witte" peptone is shown to be best suited for adjustment of the reaction by titration with phenolphthalein.

4. The addition of 0.5 gram of KCl per 100 cc. of solution causes no change in the buffer action of the peptone solutions.

5. Results and curves obtained in the determinations of optimum reactions for the growth of B. coli in media containing three grams of peptone and 0.5 gram of KCl per 100 cc. are given for eight peptones.

6. It is shown by means of comparative tests that "Witte" peptone gives best results for growth of B. coli.

7. Armour's, "Witte," and "Proteose" peptones were the only ones found suitable for use in the determination of indol production. These three are given in the order of their value for this purpose.

8. Duplicate samples of all of the peptones, obtained at a later date, gave hydrogen ion titration curves similar to those for the original samples.

REFERENCES

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(2) Clark: The Determination of Hydrogen Ions, 2nd ed., 1924.
(3) Bunker and Schuber: Jour. Amer. Water Works Assoc., ix (1922), 63.
(4) Gage and Adams: Jour. Infect. Dis., i (1904), 358.
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(11) Chamot: Proceedings of the Sixth Meeting of the Illinois Water Supply Assoc., Urbana, Ill.
(12) Tilley: Amer. Jour. Pub. Health, xi (1921), 513.
(13) Report of Committee on Standard Methods of Examining Disinfectants. Amer. Jour. Pub. Health, viii (1918), 506.

THE MELCROFT COAL COMPANY CASE[1]

During the past year, members of your Committee on Industrial Wastes in Relation to Water Supply have followed developments along the lines of the committee work and have submitted to the Chairman the information thus obtained. This information, together with that already published in the Progress Reports of the Committee, will be summarized as topic 13, in the forthcoming Manual.

The outstanding development in the field of industrial wastes in relation to water supply is the decision of the Supreme Court of Pennsylvania in the so-called Indian Creek Coal Mine Drainage Pollution Cases. In the Progress Report of the Committee, published in May 1923,[2] the subject of Pollution of Water Supplies by Acid Wastes from Coal Mining Operations was discussed and the case of Mountain Water Supply Co. vs. Melcroft Coal Co. was outlined up to that time. In view of the importance of this case, it has seemed advisable at this time to summarize the proceedings including the final status of the case.

In 1920 the Mountain Water Supply Company, the Pennsylvania Railroad Company and others filed bills in equity in the Fayette County, Pennsylvania, Court to restrain the Melcroft Coal Company and some twenty other coal companies and individuals from polluting Indian Creek with drainage from various mines on the watershed. Later the Commonwealth of Pennsylvania, through the Attorney General, was allowed to intervene as a plaintiff because of the public nature of the case.

After various legal preliminaries, the case came to trial during the summer of 1922. Both sides were ably represented by an array of legal talent and engineering experts.

Indian Creek, having a watershed of about 130 square miles, was virtually unpolluted in 1906 when the plaintiffs constructed an im-

[1] Report to Council on Standardization of Committee No. 6, on Industrial Wastes in Relation to Water Supply. Presented before the Louisville Convention, April 29, 1925.

[2] Journal, Vol. X, pp. 417–420.

pounding reservoir a few miles above the mouth of the stream to supply water to Pennsylvania Railroad locomotives and to the public. The piping system was gradually extended until at the time of the trial some 75,000 people were receiving a portion or all of their supply from the Indian Creek Reservoir, in addition to the large volumes of water used for locomotives and other industrial purposes by the railroad.

It was admitted by the defendants that drainage discharged into the stream from mines on the watershed, opened subsequent to construction of the dam, caused pollution of the stream, and that this pollution would increase with further development of mining operations.

Discharge of coal mine drainage has destroyed for domestic use numerous streams in Pennsylvania and has so altered the character of many others as to make treatment of the water difficult and expensive. In recent years this pollution has occurred without check in view of a decision of the Supreme Court of the State in the so-called Sanderson cases, which held that such discharge was permissible even though it rendered the water unfit for domestic purposes, and caused other damage to lower riparian owners. This Indian Creek case was, therefore, in effect an attempt to reverse the decision in the Sanderson cases, and naturally assumed much importance not only in Pennsylvania, but also in other states where the discharge of mine drainage causes trouble.

The Fayette County Court in a voluminous opinion rendered on December 26, 1922, held that discharge by the defendant coal companies of the water accumulating in their mines into Indian Creek was a proper and natural use of their lands, and constituted a right of property of which they could not be deprived except by due process of law; that the Mountain Water Supply Company had not lawfully acquired any of the property or property rights of the defendants, and hence its rights to the water were simply those of a riparian owner, and as such had no standing in a proceeding to enjoin the discharge of mine drainage into the stream; that the public use of the water was not a controlling factor because none of the plaintiffs had completely exercised power of eminent domain devoting the waters to public use, and finally that granting of the injunction would deprive the mine owners of their rights without due process of law. The decree of the Court refused the injunction and dismissed the case, placing the costs upon the plaintiffs.

The case was appealed to the Supreme Court of Pennsylvania, and an opinion rendered on September 29, 1924,[3] held that the lower Court was in error in holding "that to constitute a public use of the water it must be taken under the right of eminent domain"; concluded that the water was devoted to public use; that the Sanderson case did not apply, "that the defendants have no right of any kind to drain their mine waters into the stream considering the public use which is made of its waters, and that their so doing constitutes a nuisance which must be restrained."

The decree of the lower Court was reversed, and it was directed to enjoin the defendants from "discharging, pumping or causing or permitting to flow or to be discharged, any drainage of mine water from their mines, and from the mines of each of them, into the waters of Indian Creek, or its tributaries, above the dam of the Mountain Water Supply Company, after the expiration of six months from the date of the entry of the decrees. It is further directed that defendants shall pay the costs."

Following the decree of the Supreme Court of Pennsylvania, the defendant coal companies sought to have the Supreme Court of the United States review the case, stating among other reasons that the action of the State Court had deprived them of property without due process of law, and that they had been denied equal protection of law in violation of the Constitution of the United States. After hearing briefs and argument the Supreme Court of the United States refused to give consideration to the case.

Following this refusal of the Supreme Court of the United States, and in conformity with the decision of the Supreme Court of Pennsylvania, an injunction was issued by the Fayette County Court on January 29, 1925, giving the coal companies until July 30, 1925, to comply with the order of the Supreme Court and cease the discharge of mine drainage into the stream.

Sufficient time has not elapsed to gage the effect of this decision upon the coal mining industry and the mine drainage pollution problem of Pennsylvania. This much is certain, it constitutes a brake upon the indiscriminate destruction of water supplies by mine drainage, which has been carried on so long by the coal companies under the apparent protection of the Sanderson cases.

[3] Decision of Supreme Court of Pennsylvania, November, 1924. Pennsylvania Railroad Co. vs. Sagamore Coal Co.

REPORT OF STANDARDIZATION COUNCIL[1]

At the Montreal convention in June, 1920, the Association established the Standardization Council. Among its purposes have been the stimulation and development of much needed investigation and review of various features of water works practice by committees of specialists, of which it has had from 15 to 18 in active service during the past four years. Numerous committee reports have been prepared and discussed, in order to determine by an interchange of views what is most helpful among certain water works experiences for the general use of the water works industry.

While the development of such information along broad, practical lines is in itself well worth while from an educational viewpoint, a more important object sought by Council has been the standardization of water works practice in various ways. To standardize, literally, the practices in many features of the water works industry would be difficult and is probably undesirable. But it is not so formidable an undertaking to set out procedures fairly representing the different prevailing views of many water works managers and their technical collaborators. Indeed, this result has been brought about in a most gratifying way by the activities of the Council's committees and the discussion of their reports by the general membership.

MANUAL OF AMERICAN WATER WORKS PRACTICE

As indicated a year ago, there has been developed, largely through committee effort, sufficient material to bring out a first edition of a Manual of American Water Works Practice. This manual represents group effort. It is founded essentially on the committee reports and on papers with discussions presented to the Association in recent years.

During the past year, about 50 members have coöperated in the drafting of material for the Manual, subdivided into about 75 topics, as stated in The Journal of November, 1924. This has been edited, multigraphed and then sent in each instance for review to about 30

[1] Presented before and approved by the Louisville Convention, April 28, 1925.

members, including committeemen engaged in activities closely associated with the topic in question.

Coöperative work by more than 200 members has now brought to the Council fairly well reviewed manuscripts on more than 70 topics.

Next month this material will be finally edited and sent to the publishers of the Manual, The Williams & Wilkins Company of Baltimore, who expect to place it on the market early next fall as a book of about 600 pages. Due acknowledgment will be made for the aid received from those who have materially coöperated in its preparation.

This book, dealing with a large number of topics of a practical nature, is not necessarily in the final form best suited to the membership of this Association as a whole. But it is necessary to make a beginning, in order that the test of general use may show what changes are desirable. It is believed, however, that as a result of five years' earnest work, a first edition of the Manual of American Water Works Practice can now be published which will be creditable to this Association and distinctly helpful to all interested in water supply problems.

Undoubtedly the Manual, as it first appears, can be improved. Such has been the history of the notable Manual of the American Railway Engineering Association, and it is confidently expected that our Association will similarly develop a keen interest in discussing its Manual in a way to bring about improvements in later editions. In fact, the Manual will doubtless prove an excellent stimulus of discussion at annual conventions and at numerous regional and section meetings throughout the country. That has been the experience of our sister society in the railway field, which has found its Manual an effective means of uniting the men engaged in railway engineering throughout the country and in increasing the strength of their national organization.

STANDARD METHODS OF WATER ANALYSIS

The Committee of the Council having this matter in hand has coöperated with the corresponding committee of the American Public Health Association, and next fall there will appear a 1925 edition of Standard Methods of Water Analysis published jointly by this Association and the American Public Health Association.

There is much practical benefit to be derived by joint endorsement

of yardsticks of measurement, so to speak, used by the health and water laboratories. It is believed that this is an important step in advance, and as years go by it will facilitate the coördinating and harmonizing of efforts along practical lines, to the substantial benefit of all concerned.

COÖPERATIVE STUDY OF BOILER FEED WATERS

A year ago the Council approved a program for a committee of this Association to proceed in a joint undertaking with other organizations interested in the use of steam boilers. As was stated in the March JOURNAL, a central committee has been set up representing this Association, the National Electric Light Association, the American Railway Engineering Association and the American Society of Mechanical Engineers and probably some others having to do with steam power plant practice. The purpose of this joint undertaking is to bring about a more comprehensive scientific and practical knowledge of boiler feed waters from all angles. Papers and reports will be prepared and discussed within the committee and its sub-committees in a most exhaustive way. It is not expected that other than progress reports will be forthcoming for several years, during which time Council bespeaks for these joint committees dealing with various branches of the subject the hearty coöperation of the members of this Association, representing as they do a substantial portion of the steam users of the country.

It is evident from what has been said that the work of the Council up to this time has been essentially preparatory. The foundations have been laid for an executive mechanism by which the carefully considered views of our members may be discussed and then published for public use. The public is served most usefully in this way, and the Association, in turn, gains public recognition unattainable otherwise. On this account, the Council must necessarily carry forward its work of developing and improving the product of its activities to date in a conservative spirit, although without abatement of energy.

The Council desires to record its appreciation and thanks for the generous support which it has received from the membership at large as well as from its committees and those who have prepared and reviewed material for the Manual.

The personnel of the Council has been as follows:

FRANK A. BARBOUR, 1920 to date,
EDWARD BARTOW, 1920–1924,
W. S. CRAMER, 1924 to date,
W. W. DEBERARD, 1923 to date,
GEORGE A. JOHNSON, 1920–1924,
EDWARD E. WALL, 1924 to date,
GEORGE C. WHIPPLE, 1920–1923,
GEORGE W. FULLER, *Chairman*, 1920 to date,
MALCOLM PIRNIE, *Secretary*, 1921 to date,
ABEL WOLMAN, *Manual Editor*, 1924 to date.

DISCUSSION

HELPFUL TOOLS IN REMOVING METERS[1]

From this discussion it appears that Mr. H. Buck, Superintendent of the Riverton & Palmyra Water Company, took a part, describing certain facilities of which he has made use. I wish to call attention to the fact that the ruling of the Board of Public Utility Commissioners of New Jersey has been misstated.

These rulings were adopted after free and full discussion with all utilities in the State. I assume that all utilities are familiar with the requirements that meters be tested under certain conditions. This remark of Mr. Buck's led to some discussion by Mr. Heffernan and Mr. Gibson which was based on the assumption that the Commission's experts had no experience at all in such matters. I think that such would be entirely correct, if Mr. Buck had known the facts, but investigation shows that Mr. Buck had not made any tests until very recently, and because of this he has violated the rules of the Board, which was an *order*, and which went into effect originally in February, 1917.

If you would examine the rules, I think you will find that the rules themselves are based on *knowledge* which came from *experience*. In developing these rules I wish to say that I had the assistance of Mr. French of the Hackensack Water Company, Mr. Cuddeback of the Passaic Water Company, and Mr. Roth of the American Pipe & Construction Company, and some others whose names I have forgotten for the moment. They are all individuals who are well known in the fraternity.

Rule XI prescribes that periodical tests of meters are to be made as follows:

⅝-inch meters every 10 years or 750,000 gallons
¾-inch meters every 8 years or 1,000,000 gallons
1-inch meters every 6 years or 2,000,000 gallons
All meters above 1 inch, every 4 years

In addition, of course, these are supposed to be tested before and

[1] Journal, November, 1924, page 316.

after repair, and under certain conditions, upon application of customer.

Since the meters in use by the Riverton & Palmyra Water system are almost entirely $\frac{5}{8}$-inch, the implication that water meters are to be tested every three years by order of the New Jersey Commission is entirely uncalled for, and without excuse, because of the wide publicity a discussion before the American Water Works Association obtains.

PHILANDER BETTS.[2]

At the Convention held in New York City in 1924, the writer took part in a discussion under the heading "Useful Tools in Removing Meters." During this discussion the writer made the statement in part that it was the ruling of the Public Utilities Commission of the State of New Jersey that meters should be tested every three years.

My attention has been called to this statement by Colonel Betts, Chief Engineer of the Commission, advising me that this statement was incorrect. He also sent me a copy of the rulings of the Commission, wherein I find that my statement made at the Convention, was as he stated, incorrect. This, however, was not intentional on my part, as someone whom I considered an authority, told me of this three year test, but who this particular party was I cannot recall. However, I wish to correct this error on my part, and I desire to offer my apologies for making this statement, as I would not knowingly make a misstatement under any consideration.

WM. H. BUCK.[3]

[2] Chief Engineer, Board of Public Utility Commissioners, Newark, New Jersey.

[3] Superintendent, Riverton and Palmyra Water Co., Riverton, New Jersey.

ABSTRACTS OF WATER WORKS LITERATURE

Frank Hannan

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Public Health Engineering Problems in Chicago Area. Arthur E. Gorman. Eng. News Rec., **94:** 402, 1925. The Calumet river, flowing into Lake Michigan, pollutes water supply with sewage and industrial wastes 42 per cent of time, and to such extent that ordinary chlorine dose is completely absorbed. Lake shore improvements also seriously threaten water supply, creating pollution rapidly increasing beyond possibility of chlorination.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

New Tests of Loss of Head in 2-inch Black Wrought Iron Pipe. Lynn Perry. Eng. News Rec., **94:** 272–3, 1925. Results of 105 determinations of loss of head for 8 different velocities are plotted with the measurements of Saph and Schoder, Davis, and Hazen and Williams, and computations by formulas of Lampe, Kutter, Flamant, and Fanning. The slope of the author's curve is somewhat greater than that of Saph and Schoder, and corresponds more nearly to those of Davis and of Hazen and Williams. The latter appears to allow a very small factor of safety. The determinations were made by measurement of velocity and discharge, care being taken to avoid faulty piezometers and piezometer connections, these being the prevailing weak points in such investigations.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Pitting in Two Steel Standpipes near St. Louis, Mo. W. V. Weir. Eng. News Rec., **94:** 281, 1925. Condition of 2 riveted steel standpipes of West St. Louis Water and Light Co., after 16 and 21 years' service respectively, described. The former, which was put in commission about same time that coagulation with lime and iron sulphate was adopted, showed little pitting and corrosion compared with latter, which had been used for some years with Missouri river water which had been settled without coagulation. The interior surface in each case was covered with a very thin hard coating, probably a natural cement resulting from combination of the clay in the water with the lime used in coagulation, and examination of the older standpipe indicated that the pitting and tuberculation had probably occurred prior to the formation of this deposit. The rivets were attacked more than the plates and the cover of the tower was completely destroyed by rust.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Substructure Construction Methods; Buffalo Filter Plant. Eng. News Rec., **94**: 358–62, 1925. Illustrated description.—*R. E. Thompson.*

Substructure Plan and Design: Buffalo Filter Plant. Eng. News Rec., **94**: 322–4, 1925. Illustrated description of construction of 160 m.g.d. filtration, plant, the first unit of an ultimate 400 m.g.d. installation. The plant consists of coagulation basin providing 3 hours sedimentation, and 40 4-mg. filter units superimposed over a clear water reservoir. The turbidity of the raw water, drawn from the Niagara river, varies between 0 and 250 p.p.m.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Water Supply Problems for the Future Chicago. John Ericson. Eng. News Rec., **94**: 353, 1925. Estimates of future consumption, based on present values, are given, and the desirability of complete metering in order to reduce waste is emphasized. Chlorine dosage now employed is maximum permissible. Filtration cannot be adopted until waste has been reduced. —*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Report, Aberdeen Waterworks, Year Ending May 31, 1924. Geo. Mitchell. Munic. Eng., **74**: 512, 1924. Average rate of filtration was 3½ mg. per acre per day. Lime was added 74 days during the year, when river was in disturbed state after floods, during times of high consumption when filters were inadequate to deal with quantity of water required, and when filters were being re-sanded. Maximum daily consumption was 8,477,000 gallons. New purification works are under construction.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Effect of Improved Water Supplies on Typhoid Fever Death Rate. C. A. Holmquist. Cont. Rec., **38**: 1237–8, 1924. Typhoid death rate has decreased in U. S. registration area from 31.3 per 100,000 in 1900 to averages of 5.3 during 5-year period 1918–22, inclusive, and from 26.7 to 3.3 in N. Y. State. In 1906 only 700,000 people in N. Y. State were supplied with purified water, while at present time nearly 8,000,000 equivalent to approximately 73 per cent of entire population, are using treated water, the number of purification plants having increased during that period from 18 to 176. Typhoid death rate in Niagara Falls averaged 131.8 prior to installation of filtration and chlorination plants in 1911, while during past 6 years the rate was only 5.0. Similarly, average rate has decreased from 85.5 to 3.7 in Cohoes, and from 89.4 to 4.1 in Albany.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Disturbing Factors in Cement Setting. H. K. G. Bamber. Cont. Rec., **38**: 1243, 1924. Aggregates should be tested with brand of cement to be employed, as setting properties may be disturbed or destroyed by conditions which cannot be detected by chemical or physical examination. Slow setting cements are most satisfactory.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Early High Temperatures in Alumina Cement Concrete. Eng. News Rec.,

94: 320, 1924. In cold weather freshly poured concrete must be kept above temperature at which setting is retarded. This point, for Portland cement, is approximately 50°F. Measurements supporting contention that higher temperatures are developed in setting of alumina cement than in Portland cement and that the former is therefore more suitable for use in low temperatures, are given. Tests showed that heat generated in case of alumina cement was sufficient to prevent freezing until concrete had hardened and developed considerable strength.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Aluminous Cement in Practice. T. J. Gueritte. Cont. Rec., **38**: 1197–8, 1924. Advantages of aluminous over Portland cement are: greater strength; more rapid hardening and development of strength; and higher temperature developed on setting, usually sufficient to permit normal hardening even in severe weather. Slightly more mixing water is required than with Portland cement and 2–3 times as much mixing. Excess water reduces strength much more than in case of Portland cement and mix is not as plastic and requires thorough mixing and ramming. After concrete has "set off" evaporation of contained water should be prevented by frequent watering. Aluminous cement concrete is completely resistant to action of sea water, water saturated with $CaSO_4$, and 12 per cent $MgSO_4$, and is very resistant to petroleum and vegetable oils, but is attacked by acids.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Maintaining Uniformity in Concrete. Alfred S. Grunspan. Cont. Rec., **38**: 1268, 1924. Proportions should be adjusted on basis of "modulus of density," i.e., ratio of volume of binding material to voids in aggregate. Addition of active silicious material fixes the free lime, which constitutes a source of weakness, particularly in concrete exposed to sea water, highly volatile spirits, or light oils.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Lambton Now Has Modern Water Works. R. O. Wynne-Roberts. Cont. Rec., **38**: 1101–2, 1924. Description of construction of 440,000 gallon steel water tower, incased in brick, 100 feet high above 6 foot concrete foundation. Supply is obtained temporarily from Mimico, pending construction of permanent, direct and larger connection with New Toronto.—*R. E. Thompson.*

Interceptor in Suction Line Serves as Centrifugal Pump Primer. Eng. News Rec., **94**: 287, 1925. Device consists of closed steel-plate cylindrical vessel interposed between pump and suction line, with inlet from suction at top and outlet to pump at bottom, capacity being sufficient to supply pump with water until suction is full. Very satisfactory results obtained in power station in London, Eng., priming difficulties being entirely eliminated. Air remaining in interceptor prevents syphoning when pump is not in operation. —*R. E. Thompson.*

New Tables for Computing Loss of Head in Pipes. J. O. Jones. Eng. News Rec., **94**: 240–2, 1925. Tables of values of f in Chezy formula for new cast iron, old cast iron and riveted iron or steel, galvanized iron, concrete,

wood-stave, and black iron or steel pipe. Loss of head in 90-deg. screw elbow is equivalent to loss in approximately 40 diameters length of pipe; a Tee is double an Ell; globe valves, wide open, 500 diameters length; gate valves 10; an Venturi meters 100–1200, depending on ratio of throat diameter to entrance diameter, etc. Table of values of constants in formula for friction coefficient for different kinds of pipe also included.—*R. E. Thompson.*

Building the Lake Humphreys Concrete Arch Dam. CARL A. GOULD. Eng. News Rec., **94**: 315–9, 1925. Construction of dam, varying in thickness from 17 feet at base (head, 91 feet) to 3.5 feet, 5 feet above water line, on Goose Creek, described. Methods employed for protection of concrete from low temperatures outlined, most effective being flooding with warm water for 48–72 hours after pouring, forms being made sufficiently loose to permit dripping of warm water down exterior. Cost of protection varied from $1.40 to $2.00 per cubic yard of concrete. Vertical V-type contraction joints placed at intervals of 45 feet did not prevent formation of hairline cracks. Deflection of arch on filling shown graphically.—*R. E. Thompson.*

Increase of Available Water Supply with No Capital Expenditure. FREDERIC E. BECK. Cont. Rec., **38**: 1125–6, 1924. Construction program totalling $1,099,000 appeared inevitable to the Consolidated Water Co. of Utica in 1917 to meet increasing demand. Ample water was available at source, West Canada Creek, but new transmission line was necessary. Cleaning existing main increased value of C in formula of Hazen and Williams from 90 to 131 and the carrying capacity 3.8 m.g.d. This increased supply together with reduction in consumption of 2.5 m.g.d. by location of leaks by waste water survey, postponed the large capital expenditure, saving $292,895 in interest. Cost of survey and main cleaning operations totalled $16,622. The construction program will be carried out during coming year. Consumption in 1923 was 11.0 m.g.d.—*R. E. Thompson.*

Operation of Ohio Sewer District Law Since Enacted in 1911. R. F. MACDOWELL. Eng. News Rec., **94**: 227–8, 1925. Progress under Ohio Sewer District Law reviewed. Provisions for inclusion of water supplies were added in 1917. Total expenditure under law in excess of $20,000,000. Methods re-financing and assessments outlined.—*R. E. Thompson.*

Tri-State Compact for Utilization of Delaware River. Eng. News Rec., **94**: 233–4, 1925. Data given on compact between states of New York, New Jersey and Pennsylvania re-allotment and sanitary protection of water of Delaware River. Control will be vested in permanent "Tri-State Delaware River Commission" composed of not more than two representatives of each state. The compact includes provisions for compensation of low flow and impounding of flood water; rules retreatment of sewage and industrial wastes; and outline of policy of forestation and protection against fires in forestated areas. Basis of utilization will be as follows, in order of relative "importance and public value," (1) domestic and municipal, (2) sanitation, (3) industry and power, and (4) navigation. It is provided that wastes

containing taste and odor producing substances must be treated to wholly eliminate such constituents before being discharged into the river.—*R. E. Thompson.*

Large Multiple Arch Dam at Falls Creek, B. C. Cont. Rec., **38**: 1050–1, 1924. Construction of dam of Eastwood multiple arch type on Falls Creek described briefly. The dam is 680 feet in length and has overall height of 136 feet, creating reservoir of 28,000 acre feet storage capacity.—*R. E. Thompson.*

Sand Dams Built by Hydraulic Fill in Northern New York. Eng. News Rec., **94**: 180–3, 1925. Two pure sand dams, part of small hydro-electric power development on Beaver River, described.—*R. E. Thompson.*

Precipitation and Runoff at the Continental Divide. J. E. Church, Jr., and E. H. Jones. With discussion of snow surveying by H. P. Boardman. Eng. News Rec., **94**: 190–5, 1925. Discussion of apparent disparity in precipitation and runoff, involving following points: source of precipitation; increase in precipitation with elevation; effect of barrier ranges; transport of snow; instrument errors; uniformity and diversity of precipitation over wide areas and locally; re-comparison of adjusted precipitation measurements and measured runoff; probable correction factor for water losses; value of snow surveying.—*R. E. Thompson.*

Vaal River Barrage Remarkable for Its Large Gates. Eng. News Rec., **94**: 224, 1925. Brief data on Vaal River barrage given. Reservoir formed is 40 miles long and has capacity of over 16.3 billion gallons, providing net volume of 24 m.g.d. There are 35 piers, each 34 feet 6 inches high, 55 feet long and 8 feet thick, spaced to form 36 openings 30 feet wide, providing clear width 40 per cent greater than normal, this having been accomplished by widening of river at site of barrage from 620 to 1400 feet. The gates are 25 feet high and weigh 26 tons, and are counterweighted in such manner that greatest force is exerted in starting gate from seat, reversing to braking effect which brings gate to rest, operation requiring 1½ minutes.—*R. E. Thompson.*

Environmental Control in Public Health Program. Abel Wolman. Eng. News Rec., **94**: 276–8, 1925. Review and discussion of progress in sanitation, etc.—*R. E. Thompson.*

Bathing Places in New Jersey. I. K. Riker and C. W. Sparmaker. Public Health News (N. J.), **9**: 300–304; 364–371, 1924, and **10**: 88–100. 1925. A general article discussing standards of quality of pool water, construction, and operation, regulation of bathers and methods of purification and keeping of records. Tabular results for a number of New Jersey bathing places are given.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Perimeter of Protection for Drinking Water Supplies Considered from

the Hydro-geological Point of View. A. GUILLERS. Ann. d'hyg. publ., indust., et sociale, 8, 492, 1924; Bull. mens. off. internat. d'hyg. publ., 16, 1161 (1924).—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The State of the Ground Water of the Cemetery of Ohlsdorf in Hamburg. F. H. LORENTZ. Techn. Gemeindeblatt, **26**: 83, 1923; Zentrablaltt f. d. Gesammte Hyg., **6**: 252, 1924; Bull. mens. office internat. d'hyg. publ., **16**: 1162, 1924. Burial of 500,000 persons since 1886 has not sensibly affected the ground water composition. Bacterial counts are low and Bact. coli seldom found.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Studies on the Presence of Iodine in Nature. TH. VON FELLENBERG. Mitt. a. d. Geb. d. Lebensmitteluntersuchung u. hyg., **14**: 161, 1923; Zentralblatt f. d. Gesammte Hyg., **6**: 238, 1924; Bull. mens. office internat. d'hyg. publ., **16**: 1138, 1924. Results are expressed in micrograms, i.e., in millionths of a milligram. Colorimetrically 0.1 microgram iodine can be detected. von Fellenberg has perfected the colorimetric method of Rabourdin and also that of Eggenberger. Conditions in two Swiss communities were studied: Chaux de Fonds where goiter incidence was low and Signan where it was high. Drinking water of Chaux de Fonds contains 20 times as much iodine as that of Signan. Small difference was noted in iodine content in case of green foods, bread, potatoes, and apples, but the difference was in favor of Chaux de Fonds. Substances richest in iodine are codliver, watercress, leaves of green vegetables, and eggs. Poor in iodine are potatoes, cereals and turnips. Methods used permitted determination of iodine in air. Amount found was 0.04 microgram per cubic meter of air.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Natural and Artificial Biological Purification of Sewage. A. CALMETTE. Rev. hyg., **46**: 781–794, 1924.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Pollution of Rivers by Waste Waters from Blast Furnaces. GRÉLOT. Bull. des Sci. pharmacologiques, October and November, 1924; L'Eau, **17**: 138-140, 1924. Discussion of regulations.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Chlorination of the Water of Swimming Pools. ANON., Lancet, **206**: 5257, 117, 1924; Bull. mens. office internat. d'hyg. publ., **16**: 1054, 1924. Report of committee recommending chlorination.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Recent Outbreak of Typhoid Fever in Chicago. H. N. BUNDESEN. Chicago Health, **19**: 496–502, January 27, 1925. Unusual number of cases among persons of wealth, or associated with wealth. More women than men. Age largely 20–35. Majority in strip along lake front about 1 mile wide. Raw oysters eaten by $\frac{3}{4}$ of those attacked within 2 weeks prior to illness. Water and milk excluded. Oysters considered probable cause.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

New Observations on the Differentiation of Bacteria of Fecal Origin in Surface Water in the Tropics. A. D. STEWART AND R. S. GOBINDA-RAJU. Indian J. Med. Research, **11**: 1157, 1924; Bull. mens. office. internat. d'hyg. publ., **16**: 1051, 1924. Confirms Clemsha's observation that bacterial flora of contaminated water changes very rapidly in the tropics.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

General Instructions Relative to Drinking Water Prepared by Special Commission and Approved by the Superior Council of Hygiene (of France), on June 2, 1924. L'Eau, **17**: 100–104; 112–115, 1924.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

How the Laboratory Tests Water. ANON. State of Conn. Health Bull., **38**: 178–185, 1924. Illustrated description of methods employed.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Symptoms of Lead Poisoning: Their Value from the Point of Early Diagnosis and Prognosis. TELEKY. Munc. med. Woch., **71**: 266, 1924; Bull. mens. off. internat. d'hyg. publ., **16**: 328-9, 1924.—*Jack J. Hinman, Jr.*

Hygiene of Swimming Pools. AZEGLIO FILIPPINI. Annali d'Iggiene, **34**: 596, 1924; Bull. mens. office internat. d'hyg. publ., **16**: 1320–2, 1924. General paper having special reference to English and American practice.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Anticholera Injections. Vaccination against Cholera in the Philippines. A. CANTANJAL. Rev. Filipina de Medicina y Farmacia; August, 1923; Rev. d'Hyg. y de Tuberculosis (Valencia), **17**: 108, 1924; Bull. mens. office internat. d'hyg. publ., **16**: 1189–1190, 1924. Tried first in 1905. Satisfactory results reported.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

A Goiter Center in Sardinia. PAOLO OTTONELLO. Il Policlinico (sez. practica, **31**: 873, 1924; Bull. mens. office internat. hyg. publ., **16**: 1138, 1924. Cuglieri and Scano Montiferro where mountain water is used. In communities using wells there is less goiter.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Study of Public Swimming Pools. F. BORDAS. Ann. d'hyg. publ. indust. et sociale, **2**: 321, 1924; Bull. mens. office internat. d'hyg. publ., **16**: 1052–1054, 1924.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

A Hydrologic Contribution to the Investigation of the Connection between Drinking Water and Goiter. I. M. K. PENNINK. Water en Gas, August 1 to October 24, 1924; Water and Water Eng., **26**: 495–6, 1924. Suggests that schmutzdecke in filters may abstract iodine.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Purification of Sewage. ROLANTS. Rev. hyg., **46**: 811, 1924. An annual review.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Epidemics in the Department of the Doubs since 19th century, Maréschal. Rev. Hyg., **46**: 721–738, 1924. Epidemiological service created by royal decree in 1786. Much water borne typhoid fever. Cholera and typhus.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

A New Medium for the Differentiating of Typhoid and Paratyphoid Organisms. O. Hartoch and H. Schlossberger. Deut. med. Woch., **50**: 904, 1924; Bull. mens. office internat. d'hyg. publ., **16**: 1524, 1924. Four per cent agar containing 5 per cent salt is mixed with equal volume of whole or skimmed milk, mixed and filtered while hot. Sterilize by intermittent method. Bact. typhi and paratyphi A do not grow; paratyphi B and allied species do grow. —*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

A Differential Diagnosis by Culture in the Colon Typhoid Group. Joffe. Deut. med. Woch., **50**: 905, 1924; Bull. mens. off. internat. d'hyg. publ., **16**: 1524, 1924. Use of the special media of Hartoch and Schlossberger plus peptone media containing "milk salts" allows typhoid and paratyphoid organisms to be separated.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Prevention of Scale Formation by Boiler Water Conditioning. R. E. Hall, Carl Fischer and Geo. W. Smith. Iron & Steel Engineer, **1**: 312, June, 1924. In order that dry steam may be continuously delivered from a boiler and hard scale deposition eliminated, three phases relating to boiler water must be continuously controlled: (A) Conditioning of the boiler water to prevent hard, adherent scale; based entirely upon control of ratio of sulfate to carbonate or phosphate concentration and upon boiler temperature or pressure. This purely chemical function must be clearly differentiated from (B) and (C). (B) A mechanical phase consisting of removal from boiler of precipitated sludge and suspended insoluble matters resulting from chemical conditioning and evaporation. (C) A mechanical phase preventing entrainment of liquid droplets by the gaseous steam. Chemical means alleviate this condition, but more effective and economical measure is to use mechanical equipment with boiler. (A) *Prevention of Adherent Scale*: Deposition of calcium sulfate (anhydrite), and hydrous magnesium and calcium silicates must be prevented. Presence of soluble sulfates, such as sodium or magnesium sulfate, increases insolubility of calcium sulfate; therefore the greater the concentration of soluble (SO_4) radical in boiler water, the more rapid will be hard scale deposition. Insolubility of calcium sulfate and therefore its rapidity of deposition increases with boiler temperature and pressure. For this reason, hard scale is deposited at the hottest points within the tubes. Calcium carbonate on the other hand increases in solubility with increased temperature and pressure and is precipitated more readily at the cooler points in the tubes, producing a sludge or soft scale, which discharges with the blow-off water for the most part, instead of crystallizing out on the tube surface as does calcium sulfate. To retard hard scale deposition it is therefore only necessary to maintain a sufficiently low concentration of *soluble* sulfate (SO_4) in comparison to the *soluble* carbonate (CO_3) present. This is accomplished in low pressure

boilers satisfactorily by internal soda-ash treatment. In the case of high pressure boilers, it is more advantageous to remove most of sulfate content by pre-softening feed water, and rely on internal treatment for final adjustment when necessary. Internal soda-ash treatment alone in high pressure boilers fails because of rapid decomposition of the carbonate into hydroxide (caustic soda) at the higher temperature, the carbonate radical (CO_3) disappearing in the form of carbon dioxide (CO_2) along with the steam. It has been demonstrated as practical on a 545 h.p. boiler, operating at 150 pounds pressure, to control adequately the deposition of hard scale by internal treatment with soda ash alone. Feed water had a (SO_4) content of 110 parts per million, and total soluble solids 181 parts. The method, given in detail, consists in *maintaining at all times a pre-determined concentration of soluble carbonate (CO_3) for every definite concentration of soluble sulfate (SO_4) present in the water within the boiler.* Apparatus for tests is illustrated, and valuable chart of curves, intended for posting in boiler room alongside of testing apparatus, accompanies article. It shows the minimum required carbonate concentration for a given sulfate concentration, to prevent hard scale deposits. Where soda ash is unsuitable because of rapid caustic soda formation, sodium phosphate should be used instead. In boilers operating at 210 pounds or below, soda ash seems satisfactory, but above this pressure the phosphate should be used. Control is similar to that for carbonate. (B) *Removal of Sludge and Suspended Matters*: There are three methods: (1) discharge with blow-down water, (2) removal by settling or filtration of suspended solids or precipitated matter, caused by external treatment of feed water before it reaches boiler, or (3) to filter continuously portion of boiler water by recirculation through pressure filter on closed circuit with boiler, thus controlling amount of suspended matter by varying rate of filtration and in addition removing deposited sludge by "blowing-down." Charts and tabulated records indicate effectiveness of each method, most effective being preliminary soda-lime softening and filtration of feed water with continuous recirculating-filtration of boiler water, equivalent to 25 per cent of new feed water added in any given time. Next most effective method is internal soda-ash treatment and filtration by recirculation, equivalent to 25 per cent of new feed water. With former, 89 p.p.m. suspended solids could be maintained, while with latter not less than 385 p.p.m. was maintained up to 500 hours operation in each case. (C) *Prevention of Wet Steam*: Discussion of causes of wet steam. In general terms, entrained moisture in steam increases with increase of soluble and insoluble (suspended) matters in boiler water. Addition of anti-foaming compounds is effective to certain degree, but merely temporizes with conditions, and at high cost. Careful regulation of chemical feed to control hydroxide (caustic) content of water within boiler and prevention of return to it of any cylinder oils, are first steps in prevention of moisture in steam. Most effective and economical solution consists in placing mechanical steam apparatus within boiler just below steam outlets. Droplets of water are thereby separated mechanically from gaseous steam. With protection provided for out-going steam, conditions necessary for controlling scale deposition, although increasing soluble and suspended solids in water, may be imposed upon boiler

without hesitancy. With reduction of suspended matters made possible by recirculation-filtration, such operation is even more permissible. Entire program described above was carried out on 545 h.p. boiler operating at 150 pounds pressure, with resulting non-hard scale deposition and production of steam with 1 per cent or less moisture, regardless of variations of load. The feed water used contained 181 p.p.m. soluble solids of which 110 parts was (SO_4)—equivalent to 156 parts $CaSO_4$. Scientific explanation of the phase rule controlling character of precipitates to be expected under varying conditions, is clearly given and illustrated. Article contains much valuable physical-chemical information as well as valuable charts and methods. Mr. Hall of The Bureau of Mines is located at Pittsburgh, Pa. Reprints are probably available. Future number of Ind. Eng. Chem. is to contain final form of apparatus and methods for making control tests.—ABSTR.—*Linn H. Enslow.*

Correlation of Sources of Pollution. W. H. FROST. Engineers and Engineering, **40:** 12, 305, December, 1923. Correlation of the effect of pollution is only indirect since in the case of bacterial analyses the pathogens are not determined but dependence is placed upon other organisms of similar reaction. General condition of the stream as regards nuisance is measured only indirectly by chemical determinations.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Filtered Water Supply for Calcutta. Ind. and Eastern Eng., **65:** 2, 64B, August, 1924. Calcutta is facing water shortage during next three years because of insufficient filter and pump capacity in the filtration plant. Tube wells are being sunk to tide over the situation until more filters and pumps are installed.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Grand Forks: A Western Pioneer in Water Supply Treatment. JOHN G. SINCLAIR. Quarterly Jour. Univ. North Dakota, **14:** 4, 315, June, 1924. Severe typhoid epidemics occurring from 1885 to 1895 with town drawing its public water supply from a river into which domestic sewage was emptied, were checked with the installation of a slow sand filter in 1894. In 1911 a mechanical filtration plant was installed, and with continuous chlorination the problem of dealing with bacteria and organic matter is largely solved.—*A. W. Blohm.* (Courtesy *U. S. P. H. Eng. Abst.*)

Water Supply for the Farm. T. M. N. THOMSON. Plumbers Trade Journal, Steam and Hot Water Fitter's Review, **77:** 5, 376, September 1, 1924. Simple methods of supplying water to farm homes. Illustrations depict use of siphon, pump, hydraulic ram and pneumatic pressure tank in connection with obtaining the supply.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Torquay Water Works. Indian Engineering, **76:** 8, 103, August 23, 1924. Entire watershed is being planted under a regular afforestation program at the rate of 30–40 acres per year.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Algae. JACK J. HINMAN, JR. Proc. 16th Annual Convention Indiana Sanitary and Water Supply Association, 65, 1923. Southwestern Iowa experiences much trouble with algae. Dubuque remedied trouble in 7 mg. reservoir by covering. Iowa City eradicated Cyclotella by chlorination before settling.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Farm Water Supply and Sewage Disposal. CHAS. L. HUBBARD. Domestic Engineering, 108: 12, 21, September 20, 1924. Outline of equipment necessary for installing water system at a farm house. Variety of pumps described and quantities necessary for different purposes are given. Sewage disposal on farm briefly touched.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Chlorine as a Criterion of Impurity in Water. F. F. LONGLEY. Health, Commonwealth of Australia, 2: 4, 110, July, 1924. Chlorine contents of rain water in Australia show radical differences from the accepted principles, making it difficult, if not impossible, to construct and make use of a normal chlorine map.—*A. W. Blohm.*

Project for Obtaining a New Water Supply for the City of Damascus. ROUCHI SALHAB. Published (in French) by Figeh Water Commission, February 21, 1924. Two schemes for new system are pressure conduit system and siphon system. Former calls for 20-inch force main 14.1 miles long. Latter system considers construction of new collection basin and underground galleries to follow a new course a length of 9.9 miles. Pressure system to cost $800,000, siphon system $500,000.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Iodine Content of Michigan Water Supplies. E. F. ELDRIDGE. J. A. P. H. A., 14: 9, 750, September, 1924. Tests conducted principally on ground waters indicated iodine to be confined to approximately the southern half of the state, where it occurred in amounts of 2 to 5 parts per billion. Larger amounts found in a few deep wells, in mineral waters and in brines, led to the conclusion that iodine is from salt deposits, that iodine is not present to the same extent in these deposits and that it is probably present as iodides or iodates of the alkaline earth metals.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

The Revision of the Public Health Service Quality of Water Standard. H. E. JORDAN. Proc. 17th Annual Convention, Indiana Sanitary and Water Supply Association, March 6, 1924. Report of the Committee of the Public Health Service is divided into three sections: (1) Specification as to source and protection; (2) Specification as to bacterial quality; (3) Specifications as to physical and chemical characteristics. The aim was to have requirements such that a satisfactory water could be produced by the methods of normal and well recognized practice, while the consumer would be guaranteed a satisfactory product.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Some Examples of Stream Pollution in Indiana. J. C. DIGGS. Proc. 17th

Annual Convention, Indiana Sanitary and Water Supply Association, March 6, 1924. This paper details three examples of stream pollution, one a plant treating 600 to 700 tons of sugar beets per day and discharging the untreated wastes, often equal in volume to the flow of the river, into which it empties. Acid mine water drainage caused considerable trouble, shutting down steam plants, corroding mains and killing fish. In 1923 a zinc plating factory emptied 5500 gallons of zinc and cyanide wastes into a stream killing fish for a distance of 30 miles. A practical treatment has been worked out for the removal of all zinc and cyanide from the plant drainage.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Some Recent Developments in Stream Pollution. H. W. Streeter. Proc. 17th Annual Convention, Indiana Water Supply and Sanitary Association, March 6, 1924. There are two kinds of purification. One concerned with reduction of putrescible organic constituents of polluting wastes; the other a reduction in bacteria. The first depends upon the reserve supply of oxygen, which is replenished by absorption of oxygen from the atmosphere or reaeration. Bacterial purification of streams has been found to be governed by definite constants, capable of empirical determination.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

An Efficient Low-Priced Alum Feed. Local Self-Government Gazette, 10: 6, 229, June, 1924. The "Vaetch Alum Feed" is described as consisting of a wooden cage placed in a small tank or compartment through which a stream of water is passing. Volume of water is measured by submerged orifice and manometer. Lump alum is placed in the cage, and the rate of solution by adjusting the flow of water in which the alum is submerged.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Industrial Connections to City Mains. W. F. King. Proc. 17th Annual Convention Indiana Sanitary and Water Supply Association, March 6, 1924. Facts leading up to the rule of the Indiana State Board of Health against industrial water connections are enumerated. Few of many instances where such connections have led to outbreaks of disease are cited.—*A. W. Blohm.* (*Courtesy U. S. P. H. Eng. Abst.*)

Odors in Chlorinated Water. Industr. Eng. Chem., 16: 12, December, 1924. An incident which may be instructive recently occurred in Paris. The public water supply in a whole quarter had a taste attributed to phenol. A quick investigation was made to find the cause. In this quarter the water came from the Marne River, upstream from Paris, and before its distribution this water was treated by chlorination in the factory of Parc St. Maur. Above the chlorination plant, a pharmaceutical products plant accidentally emptied with its sewage the contents of a carboy of 50 kgm. of guaiacol, used in the manufacture of a sirup for colds. It seems that the action of chlorine on the water containing small quantities of guaiacol, even in very weak dilution, gives chlorine derivatives the taste and odor of which are infinitely more perceptible than the taste and odor of guaiacol. The most

interesting fact is that the trout which were used in tests, to prove that the quantity of chloride in the water was not too much, were not injured or killed as when a toxic compound or even malodorant is added to the water. This fact has been compared with a previous case where the chlorine-treated water went through pipes which had been freshly tarred and showed a disagreeable odor at the point of distribution.—*A. Wolman.*

NEW BOOK

Examination of Waters and Water Supplies. JOHN C. THRESH. Third edition, 590 pages, P. Blakiston's Son & Co., Philadelphia, 1925. The present edition has been produced by the co-authorship of Dr. John C. Thresh and Dr. John F. Beall and has been enlarged considerably over the earlier volume. The authors have accumulated a vast amount of data, but much of the material has been so poorly compiled and edited as to make it of little value for reference use. Thirty-seven pages alone have been devoted to the reporting of analyses and a number of questionnaires in their original form are given.

The portions of the text relating to chlorination, mechanical filtration, ozone et cetera are exceedingly sketchy. The almost complete absence of data covering American practice in reference to water treatment processes is noticeable. There are many excellent chapters that stand out sharply in contrast with garbled text found elsewhere in the volume. Part III, Chapter XVI, entitled, "What constitutes a pure and wholesome water," should be of particular interest to sanitarians in this country. In this chapter, the authors discuss interestingly a number of problems relating to the chemical impurities carried by water. Chapters XXIII, XXIV and XXV relating to the "Physical," "Microscopical" "Biological," and "Chemical" examination have been well prepared. Water analysts who desire to compare English and American methods will find these chapters instructive.

The appendix contains 36 plates showing a large number of organisms obtained by microscopical analysis of water samples from various sources. These plates although not colored, have been reproduced well.

It is to be regretted that the authors of this book have not correlated the text more carefully. The work in many respects is highly commendable, but much of its value as a reference book has been lost due to the defects noted above.—*S. T. Powell.*

SUBJECT INDEX

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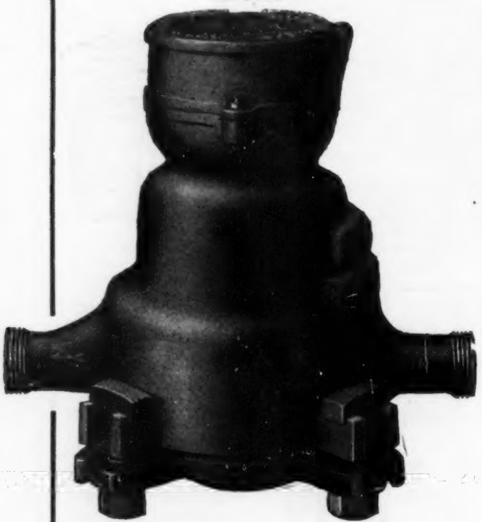

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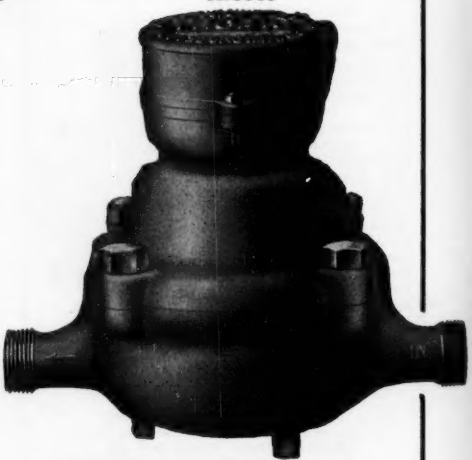

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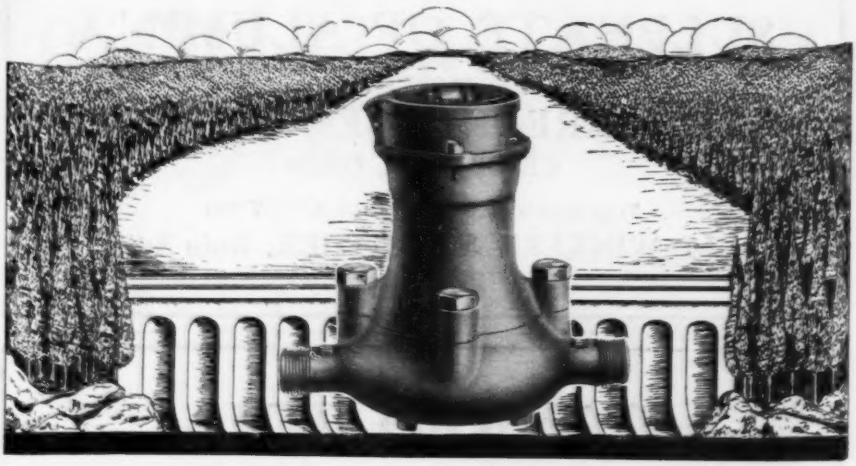

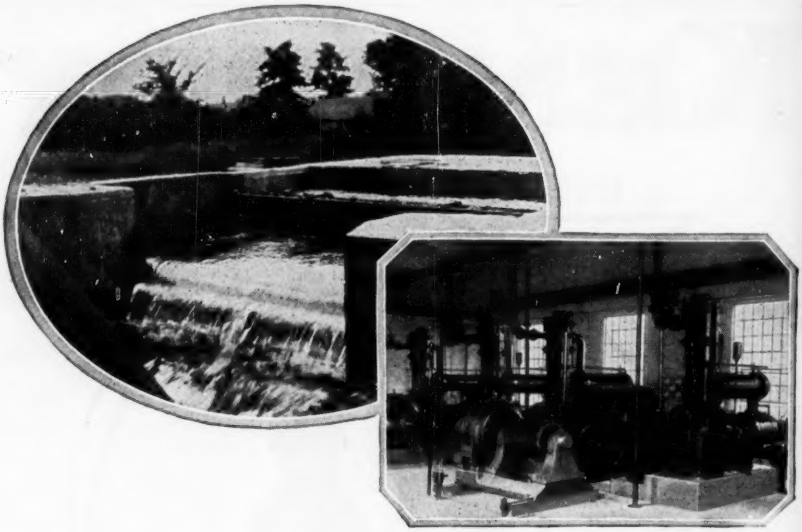


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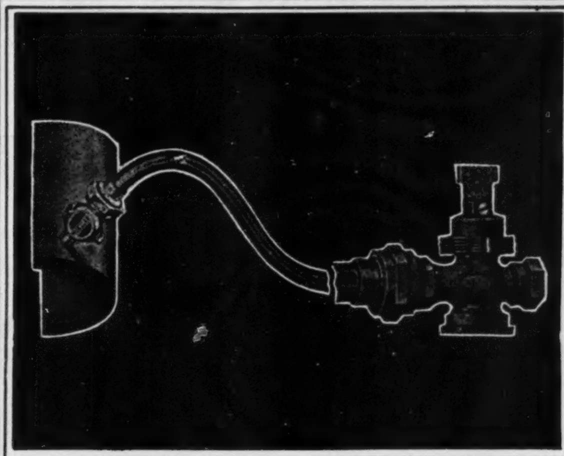


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